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No. 5 Original

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

THE STATE OF COLORADO, COMPLAINANT,

vs.

THE STATE OF KANSAS AND THE FINNEY COUNTY WATER USERS' ASSOCIATION, A CORPORATION, DEFENDANTS.

APPENDIX "A" TO BRIEF FOR COMPLAINANT.

ANALYSIS OF EVIDENCE,
AS RELATED TO SPECIAL MASTER'S REPORT.

RELATION OF VOLUMES AND PAGES OF TRANSCRIPT.
LIST OF WITNESSES.
INDEX OF EXHIBITS.

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ANALYSIS OF EVIDENCE AS RELATED TO SPECIAL MASTER'S REPORT

WATER SUPPLY

The headwater sources of the Arkansas River are in the Rocky Mountains of Central Colorado, from whence it flows eastward across the Great Plains of Eastern Colorado and Western Kansas, and, in Central Kansas, turns southward to leave that state at its southern boundary.

It has a length in Colorado of 320 miles, exclusive of tributaries, and crosses, in downstream order, the counties of Lake, Chaffee, Fremont, Pueblo, Crowley, Otero, Bent and Prowers (Colorado Exhibit 30, vol. III, p. 410; App. "B," p. 1). In Kansas its length is 390 miles, and crosses the counties of Hamilton, Kearney, Finney, Gray, Ford, Edwards, Pawnee, Barton, Rice, Reno, Sedgwick, Sumner and Cowley (Colorado Exhibit 31, Tr. vol. III, p. 411; App. "B," p. 2).

Total land areas in the basin in the two states aggregate 46,823 square-miles, of which 24,628 square-miles are in Colorado (Colorado Exhibit 205, Tr. vol. XXXVII, p. 6607; App. "B," p. 59), and 22,195 square miles are in Kansas (Colorado Exhibit 31, Tr. vol. III, p. 411; App. "B," p. 2). The 22,195 square-miles of tributary area in Kansas includes 1,200 square-miles at the headwaters of Bear Creek and White Woman Creek in Colorado, the runoff from which flows from Colorado into Kansas in channels other than the Arkansas River. Bear and White Woman creeks are independent stream systems the flows of which disappear in Kansas and have no direct surface connections with the Arkansas or other principal rivers.

The above described drainage area of the Arkansas River basin is exclusive of areas in Colorado and Kansas drained by the Cimarron River, a tributary entering the Arkansas River in Oklahoma; and the drainage area in Kansas is exclusive of lands in that state drained by the Verdigris River and the Neosho-Grand River, both of which

have their sources in Eastern Kansas, but join the Arkansas River in Oklahoma.

The Arkansas River is formed by the junction of branches known as East Fork and Tennessee Fork with Lake Fork, at a point near Leadville, in Lake County, Colorado, where the elevation approximates 10,000 feet. These headwater branches extend up to elevations of 10,500 to 12,000 feet at mountain passes across the Continental Divide, and up to more than 14,000 feet at the crests of highest mountain peaks. (Tr. p. 347, vol. III.) Thence for a distance of about 130 miles the river is a typical mountain torrent, descending rapidly, with a gradient of 40 feet per mile, down to elevation 5,363 feet at Canon City (Tr. p. 505, Vol. IV), where it emerges from the mountains via the Royal Gorge. Thence across a foothill region to Pueblo and across the High Plains of Eastern Colorado, it descends, with a gradient averaging 10 feet per mile, to elevation 3,345 feet at the Stateline between Colorado and Kansas (Tr. p. 506, Vol. IV). Across Kansas the river channel descends, with a gradient averaging 6 feet per mile, to elevation 1,000 feet at the southern boundary of that state (Tr. p. 506, Vol. IV).

The climatic conditions are widely different in various subdivisions of the basin.

In the mountainous headwater regions, local topography and altitude affect the amount and character of natural precipitation, causing wide differences often within distances of relatively few miles. Here the annual precipitation is least in sheltered valleys, where averages range downward to 10 inches or less, and is greatest at the crests of mountain ranges and peaks, where averages range upward to 20 or 30 inches or more, much of which is in the form of snow (Colorado Exhibit 202, Tr. vol. XXXVII, p. 6602; App. "B," p. 52). The limited mountain areas receiving such higher amounts of precipitation are themselves too high and cold, and generally too steep, rocky and rough to be valuable for agricultural purposes other than grazing of livestock during mid-summer months. The

melting snows from such areas during periods of a few weeks in late-spring or early-summer months, however, constitute the sources of perennial stream flows. These snow-melt periods, and the runoff and stream flows resulting therefrom, are frequently referred to as the "June-rise."

To the east of the Rocky Mountains across the Great Plains region, differences in local topography are minor in their extent and unimportant in their effects in causing material variations in rates of natural precipitation which principally, is rainfall rather than snow, and to a large extent occurs in the form of occasional intense down-pours often termed cloudbursts. Over this plains region there is a definite trend of increasing amounts of precipitation to the east. The following Table 1, compiled from Colorado Exhibit 202 (Tr. vol. XXXVII, p. 6602; App. "B," p. 52), shows the amounts of precipitation recorded by the United States Weather Bureau in the average year of the period 1908 to 1938 inclusive, at stations in Colorado and Western Kansas listed in the order of their relative locations along the Arkansas River.

Table 1

Precipitation at Stations along Arkansas River In Colorado and Western Kansas

Values in Inches Annually — Averages 1908-1938

Station	Inches
Buena Vista	10.28
Salida	12.20
Canon City	12.87
Penrose	11.88
Pueblo	11.37
Ordway	11.05
Rocky Ford	11.24
La Junta	13.35
Las Animas	12.61
Lamar	14.77
Holly	14.33
Average of 11 Colorado Stations	12.31
Syracuse	17.12
Lakin	14.62
Garden City	18.27
Cimarron	19.19
Dodge City	19.00
Average of 5 Western Kansas Stations	17.64

From Colorado Exhibits 15 and 16 (Vol. 1, pp. 57, 58) it appears that normal precipitation up to 1929, averaged annually:

at Larned (Pawnee County, Kansas)....22.81 inches
at Hutchinson (Reno County, Kansas)...27.46 inches
at Wichita (Sedgwick County, Kansas)..30.66 inches

and at stations in the areas of the Verdigris and Neosho-Grand rivers in Eastern Kansas, but tributary to the Arkansas river, the average ranged from 32 to 40 inches annually.

Precipitation is the one original source of the stream flows and water supplies of the interstate stream; and inadequacy of natural precipitation creates the necessity for irrigation of lands and artificial applications of moisture to soils and crops in the aid of agriculture.

In the eastern Colorado portion of the Arkansas River basin, natural precipitation is least, climatic conditions are most arid, the need for irrigation is greatest, and yet the supplies of water locally produced by precipitation are least. (Tr. pp. 414, 473, Vol. III.) Here, the function of irrigation is truly one of reclamation. Irrigation is *necessary* for the successful production of agricultural crops and for the permanent occupation of the region. Established civilizations are and must remain largely if not unalterably dependent on continuing the practices of irrigation and of the diversion and use of water, without which the lands, under prevailing climatic conditions, would revert to unproductive and unoccupied desert lands.

Eastward, with increasing amounts of natural precipitation, there is relatively less need for irrigation and relatively less dependence on the practice. In Central Kansas irrigation is neither generally practiced nor an important feature of agricultural operations. Its limited extent and more or less complete absence is not, however, due to a lack of locally available supplies of water, but rather is attributable to lack of need for irrigation. Local rainfall is relatively large in amount, producing abundant water supplies, but at the same time satisfying directly the requirements of agriculture for moisture without the aid of irrigation. Such artificial watering of lands and crops as may be practiced under humid climatic conditions serves the function, not of reclamation but of a form of insurance against occasional drouths, or to increase yields and profits from lands already occupied, relatively valuable, and generally productive without the aid of irrigation.

Western Kansas, where climatic conditions are intermediate between the relatively arid climate of Eastern Colorado and the relatively humid climate of Central Kan-

sas (Tr. p. 414, Vol. III), is a zone or belt of country in which the success of agriculture without irrigation fluctuates with climatic cycles. In some years and cycles when drouth conditions are severe this intermediate zone experiences climatic conditions such as commonly prevail in Eastern Colorado, while in more favorable cycles the climate more nearly resembles that of Central Kansas. Colorado Exhibits 14-20 (Tr. pp. 57-99, Vol. I). Colorado Exhibits 38 and 41 (Tr. 563, 570, Vol. IV). Colorado Exhibit 490 (Tr. p. 6485 Vol. XXXVII.)

All ditches in the State of Kansas that divert water from the channel of the Arkansas River for irrigation purposes are located in Hamilton, Kearney and Finney counties, in the extreme western portion of Western Kansas, between the Colorado line and Garden City in Finney County (Tr. p. 6653, Vol. XXXVII). In this territory the rainfall at stations along the Arkansas River averages 15 to 18 inches annually.

Some irrigation is practiced further eastward in Kansas, as in the vicinities of Dodge City and Larned, the water supplies for which are derived from ground waters or from the flows of tributary streams arising in Kansas, but not from the Arkansas River, (Tr. pp. 3544-3546, Vol. XXI).

The quantities of water flowing in the Arkansas River at various stations have been measured and recorded for periods, at some stations in Colorado, of more than 50 years, and at other points for shorter periods. For purposes of comparing the stream flows at one point with those at other points, it is essential, to avoid distortions caused by variations in climatic conditions, that the same period of years be employed at all stations. In the following Table 2, the recorded flow at principal stations and points along the Arkansas River have been averaged over the 31-year period 1908 to 1938. The period beginning with 1908 was selected because the original case of *Kansas v. Colorado* was decided in 1907, and records disclosing the stream flows crossing the Stateline from Colorado into

Kansas began to be compiled in October 1907 with the establishment of a stream-gaging station by Colorado at Holly, near the Stateline. Table 2 summarizes information regarding drainage areas upstream, and concerning annual flows in the average year of the 1908-1938 period, expressed in acre-feet and equivalent rates in cubic feet per second, of the Arkansas River at principal stations and points.

Table 2

Discharge of Arkansas River
At Principal Stream-Gaging Stations
(Averages for Period 1908-1938)

Name of Station Point on Stream	Upstream Area (Sq. Mi.) (a)	Average Discharge A.F./Yr. (b)	C.F.S.*
Canon City, Colo.	3,090	519,767	719
(Adjusted)	3,090	573,964(c)	794
Pueblo, Colo.	4,730	502,764	695
La Junta, Colo.	11,470	189,180	262
(Purgatoire River)	(3,320)	(96,416)	(133)
Caddoa Dam	18,180	295,710	409
Lamar, Colo.	18,838	193,640	268
Stateline (Colo.-Kans.)	24,628	260,742(d)	361
Garden City, Kans.	29,893	171,050(e)	237
Stateline (Kans.-Okla.)	46,823	1,460,000(f)	2,019

(a) Drainage areas from Colo. Ex. 205 (App. "B," p. 59) and Colo. Ex. 30, 31 (App. "B," p. 1, 2) (corrected).
(b) All discharges from Colo. Ex. 204 (App. "B," p. 54-58) except as otherwise noted.
(c) From Kans. Exh. 134; (App. "B," p. 73) records adjusted to allow for by-passed quantities and imported waters.
(d) Station established Oct. 1907; after 1923 includes also waters delivered via Holly drain.
(e) Station below all ditches in Kansas diverting from Arkansas River for irrigation purposes.
(f) Adjusted to 1908-1938 average from value 1,703,144 A. F. representing average for 1922-1931 (Tr. p. 5759, vol. XXXII); does not include about 4,000,000 A. F. annually produced in Kansas which flows via Verdigris and Neosho-Grand rivers from Kansas to Oklahoma and there into Arkansas River.

*One cubic foot per second running continuously for one year equals 723 Acre Feet, (Approximately 1 c.f.s. for 24 hrs. equals 2 acre-feet).

Runoff from the mountainous areas upstream from Canon City, each year of the period from 1908 to 1938, is shown in the following Table 3. Recorded flows at Canon City have been adjusted by allowances, as made in Kansas Exhibit 135 Tr. (vol. XXXIX, p. 7024; App. "B," p. 74), for quantities of water by-passed around the Canon City station by ditches diverting above, and for quantities imported to the Arkansas River from adjoining stream systems.

Table 3

Arkansas River at Canon City: 1908-1938
Station Records Adjusted by Allowances for
By-passed and Imported Quantities of Water

			Six-Year Period Averages	
	Acre-Feet	% Avge.	Acre-Feet	% Avge.
1908	396,271	69.0		
09	701,970	122.3		
1910	567,408	98.9		
11	701,618	122.2		
12	671,535	117.0		
13	485,752	84.6	587,430	102.3
14	721,900	125.8	641,700	111.8
1915	546,000	95.1	615,700	107.3
16	685,620	119.5	635,400	110.7
17	670,580	116.8	630,230	109.8
18	636,920	111.0	624,450	108.8
19	639,250	111.4	650,040	113.3
1920	688,640	120.0	644,500	112.3
21	717,850	125.1	673,140	117.3
22	560,310	97.6	652,260	113.6
23	701,890	122.3	657,480	114.6
24	671,000	116.9	663,160	115.5
1925	427,900	74.6	627,930	109.4
26	547,540	95.4	604,420	105.3
27	600,700	104.7	584,890	101.9
28	569,430	99.2	586,410	102.2
29	628,420	109.5	574,160	100.0
1930	521,200	90.8	549,200	95.7
31	342,349	59.6	534,940	93.2
32	518,097	90.3	530,030	92.3
33	448,698	78.2	504,700	87.9
34	310,238	54.1	461,500	80.4
1935	515,306	89.8	442,650	77.1
36	627,419	109.3	460,350	80.2
37	416,220	72.5	472,660	82.4
38	554,850	96.7	478,790	83.4
AVGE.	573,964	100.0		

Stream flows in above-average amounts occurred in 15 of the 31 years of the period, and of these there were six years during which the quantities were 20 percent or more above average. Greatest discharge in any one year exceeded the average by 26 percent. Considered by periods of six consecutive years, the largest outflows from mountainous areas, recorded during 1916 to 1921, were 17 percent above the period average.

Consulting the columns of Table 3 relative to six-year period averages during each of the said periods, beginning with the one of 1908 to 1913, to and including the one of 1924 to 1929, the mountain runoff was equal to or in excess of the long-time average quantity; and thereafter, that all six year periods were sub-normal. Compared with the average of 611,000 acre-feet per year that prevailed during 1908 to 1930, the average declined to 466,000 acre-feet per year during 1931 to 1938.

After its emergence from the mountains, the Arkansas River follows a channel several hundred miles in length across the Great Plains. Its channel is a broad and widening expanse of sand, meandering over a flood plain of even greater width, underlain with sands and gravels of considerable depth and great powers of absorption. Tributaries that traverse the Great Plains have similar, though smaller, stream channels, adjoining bottom lands and underflow conduits. Floods of major magnitude and intensity such as periodically originate in foothills and plains areas, in first one and then another of the tributaries, are absorbed and diminished in volume as they move downstream. Moderate floods often are lost or disappear in relatively short distances. Perennial stream flows that originate in high mountains of tributary headwaters, upon arrival at foothill and plains sections, decrease in volume and at times disappear altogether. Perennial flows in the main stream, after their emergence from the mountains, are similarly decreased in amount and, at times, disappear. (Tr. pp. 3361-3362, Vol. XX) (Master's Report, pp.3-8.)

Such declines in stream flow volumes and disappearances of rivers are the result not only of variability of precipitation but of natural conveyance losses and of evaporation, — a natural process by which water is converted to vapor and returned to the atmosphere. Water is evaporated directly from exposed surfaces of streams. It is evaporated from the surfaces of sand beds in and along the river channels, and, aided by capillarity, from the surfaces of bottom lands that overlie the gravel filled underflow conduits adjoining and inter connected with the stream channels. Water is also taken from the streams and returned to the atmosphere by the companion process of transpiration incident to the growth of trees, shrubs, weeds, grasses and native vegetation along stream channels and adjoining bottom lands. Their supplies of moisture are obtained via root-systems from the ground waters which, in turn, in arid regions, are recharged from surface flows. Thus the sand beds of the channels and the gravels of underlying and adjoining formations act, through absorption, as a form of temporary storage, increasing the time during which conveyance losses and evaporation take place, and expanding or contracting the effective evaporation area so as to maintain a balance between the inflows thereto, contributed by the surface flows, and the outflows therefrom, consisting of the sum of the consumed and unconsumed waters (Tr. pp. 3363-3365, Vol. XX). Natural conveyance losses in the main river channel, Pueblo to Stateline, approximate 125,000 acre-feet annually (Tr. p. 3696, Vol. XXII).

Total water production in the Arkansas River basin in Colorado as reported by the Master, approximates 1,240,000 acre-feet in an average year. The Master further finds: "the average annual dependable and fairly continuous water supply and flow of the Arkansas River and its tributaries is 1,110,000 acre-feet," (page 10, Master's Report). The Master must have taken this amount from the testimony of Kansas' witness Meeker. Mr. Meeker claims to have computed the total water production in two different ways. Both methods necessarily involve es-

timated and assumed values, (Tr. p. 3644, vol. XXII). His first method involved summations of total stream flows at or near their sources, and his total (Kansas Exhibit 35, Tr. vol. IX, p. 1490), of 1,290,000 acre-feet annually, was subdivided 949,000 acre-feet of mountain runoff and 341,000 acre-feet of plains runoff. Plains runoff, involving 24 percent of the total, was necessarily estimated by applying to the plains drainage area an assumed rate of average annual runoff per square mile of drainage area. Portions of the so-called mountain runoff, similarly, were unmeasured and required estimation. Actually measured items aggregate 684,000 acre-feet, or 53 percent of the total water production as estimated under this first method (Tr. p. 3645, vol. XXII). Under the second of the two methods, the unconsumed outflows crossing the Stateline, averaging 300,000 acre-feet per year during 1912 to 1930, were added to the quantity estimated to have been consumed in Colorado, namely, 940,000 acre-feet per year, giving the total of 1,240,000 acre-feet (Tr. pp. 3693-3698, vol. XXII).

Colorado's witness Patterson, on cross examination, gave an opinion that the total water supply of the Arkansas River in Colorado averaged 960,000 acre-feet per year, (Tr. pp. 3695, vol. XXII). The records show that, during 1912 to 1930, the unconsumed Stateline outflows averaged 300,000 acre-feet; that total consumption of water, incident to diversions from and conveyance losses along the main river channel, averaged 666,000 acre-feet per year; and that the said consumed and unconsumed quantities of main river water together totalled 966,000 acre-feet, or substantially the same as the Patterson estimate of 960,000 acre-feet. The difference of about 300,000 acre-feet between the Meeker and Patterson estimates is due primarily to the inclusion by Meeker of about 300,000 acre-feet of consumptive use assumed to occur, not along the main river, but in tributary areas. Included in the Patterson total of the main river supply are the actual tributary inflows thereto; after their diminution in tributary channels by natural conveyance losses and by consumption incident to

irrigation under senior rights on such tributaries. Hence, the 960,000 acre-feet figure properly represents the total water supply of the Arkansas River (Tr. p. 3695, vol. XXII). If no irrigation uses at all had been made along the main river, about 835,000 acre-feet thereof might have reached the Stateline, — the remaining 125,000 acre-feet being lost in conveyance of the Stateline. (Colo. Exhibit 156—Tr. p. 3653, Vol. XXII).

ALLEGED INCREASED DEPLETION BY COLORADO

The Master finds (p. 9—Master's Report) a material increase in river depletion by Colorado since the taking of testimony in Kansas v. Colorado, in 1907. The finding does not state any amount of increase nor any figures of comparison of flow between 190- and now.

The Master finds (Master's Report p. 10) that an increase in the irrigated acreage necessarily reflects a decrease in the stateline flows.

The facts are that, there was an increase both in acreage and stateline flow. Taking the period from the beginning of the measurement of the stateline flows to the present, the United States Census shows that the Colorado irrigated acreage in the Arkansas basin was 464,236 in 1909 and 469,168 in 1939 (Colorado Exhibit 206, Tr. Vol. XXXVII, p. 6677).

It was alleged in the Bill by Kansas in *Kansas v. Colorado*, 206 U. S. 46, 52:

> "By the year 1891 all the natural and normal waters and a large portion of the flood waters of the Arkansas River were so appropriated, diverted, and actually applied (to distant and non-riparian lands in Colorado) so that the average flow of the river was greatly and permanently diminished and the normal flow of the river, exclusive of floods, was wholly and permanently destroyed;" and that, "the water for the irrigation ditches in the western part of Kansas

has been entirely cut off," * * *, "and the ditches are left dry and the lands uncultivated."

The court, in its opinion of May 13, 1907, summing up those matters which seemed most clearly proved, among other things said, with respect to stream flows:

> "That there is a great variance in the amount of water flowing down the channel at different seasons of the year and in different years is undoubted; that at times the entire bed of the channel has been in places dry is evident from the testimony." (206 U. S. p. 115).

And with respect to the irrigation ditches in Kansas:

> "At one time there were some irrigating ditches in these western counties, which promised to be valuable in supplying water, and thus increasing the productiveness of lands in the vicinity of the stream, and it is true those ditches have ceased to be of much value, the flow in them having largely diminished." (206 U. S. p. 113)

Conditions since 1907 are shown by Colorado Exhibits 208-215, (Tr. pp. 6639-6673, Vol. XXXVII; App. "B," p. 60-67). The witness Meeker, in behalf of the State of Kansas, testified that the stream flows in Kansas at the time of and prior to the original litigation, commencing with the year 1895, were several hundred thousand acre-feet annually greater in amount than in subsequent years and cycles of years, and that the water supplies then available to the Kansas ditches were large and adequate in amount.

Colorado's witness Patterson testified that the status of irrigation in Western Kansas today is vastly improved over what it was in 1910, and over the conditions, as shown by records, that prevailed in 1901 and years prior thereto. All ditches then functioning are operating today and serving greater acreages; all such ditches have been enlarged in capacity; one reservoir has been constructed, known as

Lake McKinnie, which has been of great benefit; that a considerable development of ground water supplies by pumping plants has occurred, greatly benefiting irrigation in the area; but that neither reservoir storage nor ground water developments have as yet been fully developed to their limits; as methods for providing additional and supplemental water supplies for irrigation purposes in Kansas, (Tr. p. 3448, Vol. XX).

As of the year 1893, the expansion of irrigation along the Arkansas River in Colorado, as to construction of new ditches and canals, for purposes of direct diversion, came to an end. Adjudicated direct flow water rights in Colorado on the Arkansas River, listed in Kansas Exhibit 2 (Vol. VI, p. 908), involve a total of 7,415 cubic feet per second, of which 6,861 cubic feet per second, or more than 92 percent have dates senior to 1894. By districts the said adjudicated direct flow water rights in the Arkansas River in Colorado, as summarized from Kansas Exhibit 2, are as follows:

Table 3a

Quantities in Cubic Feet per Second

Water Districts	Senior to 1894	1894 and Later	Combined Totals
11	363.02	31.07	394.09
12	521.43	27.23	548.66
14	2,024.44	7.00	2,031.44
17	2,399.60	401.72	2,801.32
67	1,552.35	87.20	1,639.55
Totals	6,860.84	554.22	7,415.06

In Water District 11, the total appropriations from the Arkansas River of 394.09 cubic feet per second, include 363.02 cfs. with dates senior to 1894. Of the remaining 31.07 cfs. subsequently appropriated, the latest priority is of date June 1, 1897.

In Water District 12, total appropriations of 548.66 cfs. include 521.43 cfs. with dates senior to 1894. Of the 27.23 cfs. subsequently appropriated, 2.40 cfs. thereof represents an enlargement of a previously constructed irrigation ditch (dated August 1, 1896), and the balance was appropriated during years from 1897 to 1909 for refinery, smelter, railroad, power, and related industrial purposes, which largely are non-consumptive in character. Of these industrial appropriations (in Water District 12) 15.31 cfs. thereof are dated in 1897; 0.52 cfs. from 1901 to 1904; and 9.00 cfs. thereof as of March 15, 1909.

In Water District 14, total appropriations of 2,031.44 cfs. include 2,024.44 cfs. dated earlier than 1894, and the remaining 7.00 cfs. represents an enlargement dated in 1894, of a ditch originally constructed in the 1860 decade.

In Water District 17, total appropriations of 2,801.32 cfs. include 2,399.60 cfs. with dates senior to 1894, and 401.72 cfs. with dates from 1903 to 1909, consisting of three items, as follows: (1) 334.92 cfs. to Otero Canal dated February 2, 1903, in virtue of its enlargement, to capture flood waters and to permit of diversions of storage waters released from its Clear Creek Reservoir. Diversions for direct applications by Otero Canal are accomplished, principally, under its construction appropriation for 123.0 cfs. dated August 31, 1893. Its enlargement appropriation functions an average of but 12 days per summer season, and then only fractionally (Kansas Exhibit 7, Vol. IX, p. 1345); (2) 22.0 cfs. dated November 30, 1907, represents developments of ground waters by pumping plants, and not diversions directly from Arkansas River; (3) 44.8 cfs. dated April 15, 1909, represents enlargement of Consolidated Ditch which was originally constructed prior to 1884 and has priorities as of March 13, 1888 and senior thereto aggregating 129.80 cfs., under which its diversions are largely made. Its extension priority dated April 15, 1909 functions an average of but 3 days annually and then only fractionally.

In Water District 67, total appropriations of 1,639.55

cfs. include 1,552.35 cfs. of dates senior to 1894, and 87.20 cfs. of subsequent dates, consisting of two items: (1) 7.20 cfs. to the Sisson Ditch dated December 1, 1895, representing an enlargement of its construction appropriation for 18.0 cfs. dated December 1, 1891; and (2) 80.00 cfs. to the Fort Bent Ditch (initially constructed as of April 1, 1886), representing an enlargement appropriation which functions an average of about 17 days per year (Kansas Exhibit 7, Vol. IX, p. 1345).

Along tributaries of the Arkansas River in Colorado in all Water Districts 10 to 19, (inclusive) and 67, total appropriations for direct diversion aggregate 17,676.02 cubic feet per second, of which 14,941.40 cfs., or about 85 percent thereof, are dated prior to the year 1910. Included therein are the early appropriations of the decades of 1860 and 1870 previously mentioned. The remaining 2,734.62 cfs. of adjudicated direct flow diversion rights are necessarily of the flood-water character, the effect of which on total water supplies is but a small fraction of the indicated 15 percent. (Tr. pp. 3343-3450, Vol. XX).

The total decreed capacities of the approximately 200 reservoirs in Colorado amount to 653,427 acre-feet (Kansas Exhibit 3, Tr. Vol. VI, p. 908), and of the one reservoir in Kansas to about 25,000 acre-feet. The total given for the Colorado reservoirs is exclusive of 82,100 acre-feet of unavailable decreed capacity in Great Plains reservoirs; is exclusive of the conditional decreed rights shown in Kansas Exhibit 3, (Tr. Vol. VI, p. 908) which to date have not been constructed; and includes some reservoirs which though once constructed and operated have since been washed out and are now inoperative. Of the said total capacity in Colorado, 589,018 acre-feet thereof, or more than 90 percent, bear dates senior to the year 1910. Less than 10 percent of the appropriations for storage purposes are dated subsequent to 1909.

Of the total adujdicated storage capacity in the Arkansas River basin in Colorado 415,786 acre-feet thereof, or about 64 percent, attaches to the nine reservoirs con-

structed by the five main-river ditch systems, namely, the Amity, Fort Lyon, Holbrook, Otero and Colorado systems. Together they serve nearly two-thirds of all the lands irrigated along the Arkansas River from Pueblo County to the Kansas Stateline. The said nine reservoirs provide supplemental supplies for the lands under the several main-river ditches which also have direct diversion appropriations as previously summarized. A brief outline of these five major ditch systems, and their appropriations for direct diversions (Kansas Exhibit 2, Tr. Vol. VI, p. 908) and storage (Kansas Exhibit 3, Tr. Vol. VI, p. 908) is as follows:

Amity Canal, construction appropriation 283.50 cfs. as of February 21, 1887; enlargement appropriation 500.0 cfs. as of April 1, 1893; utilizes Great Plains reservoirs, total decreed capacity 265,552 acre-feet, of which 82,100 acre-feet unavailable, leaving 183,452 acre-feet of available capacity, with construction appropriation dated August 1, 1896 (deliveries to lands commenced 1898); reservoirs supplied from Arkansas River, via Kicking Bird Canal and enlargement of Ft. Lyon Canal.

Ft. Lyon Canal, construction appropriation 164.64 cfs. as of April 15, 1884; enlargement appropriations 597.16 cfs. as of March 1, 1887, and 171.20 cfs. as of August 31, 1893; later (1897) enlarged to total capacity of about 1800 cfs. to carry storage water to Kicking Bird Canal and Great Plains reservoirs. For its own lands, two reservoirs constructed: Adobe Creek, construction appropriation 61,575 acre-feet as of January 25, 1906, enlargement appropriation 25,425 acre-feet as of December 29, 1908; and Horse Creek, construction appropriation 26,887 acre-feet as of January 25, 1906, enlargement appropriation 1,113 acre-feet as of January 12, 1908; Adobe Creek reservoir supplied by feeder canal from Adobe Creek, Horse Creek reservoir supplied by feeder canal from Horse Creek, and both supplied from Arkansas River via Ft. Lyon storage canal. (Note: diversion capacities for storage purposes of Ft. Lyon Storage Canal and enlargement for storage

purposes of Ft. Lyon Canal were not included in previously mentioned capacities and appropriations for direct delivery.)

Holbrook (Lake) Canal, construction appropriation 155.0 cfs. as of September 25, 1889; enlargement appropriation 445.0 cfs. as of August 30, 1893, incident to construction of two reservoirs: Holbrook No. 1, construction appropriation 4,276 acre-feet as of March 2, 1892, enlargement 3,196 acre-feet as of September 15, 1909; and Dye Lake, construction appropriation 4,500 acre-feet as of October 10, 1903, enlargement 3,486 acre-feet as of September 3, 1909.

Otero Canal, construction appropriation 123.0 cfs. as of March 3, 1890; enlargement 334.92 cfs. as of February 2, 1903, incident to construction of Clear Creek reservoir (in mountains), construction appropriation 9,420 acre-feet as of June 12, 1902, enlargement 2,308 acre-feet as of August 20, 1910 (attained merely by increasing the level of spillway crest); and incident to extension of Otero Canal to serve lands south of La Junta, which extension subsequently was abandoned due to inadequate water supplies.

Colorado Canal, construction appropriation 756.28 cfs. as of June 9, 1890; for direct irrigation and for storage in two reservoirs; Lake Henry, construction appropriation 6,355 acre-feet as of 1891, enlargement 3,561 acre-feet as of May 15, 1909; and Lake Meredith, construction appropriation 26,028 acre-feet as of March 9, 1898. System also includes Twin Lakes reservoir, on Lake Creek in mountains, with construction appropriation 20,645 acre-feet as of December 15, 1896, enlargement 33,807 acre-feet as of March 29, 1897. To supplement the chronically deficient water supplies of the system, and to recover lands that could not be irrigated during recent drought cycle, an importation project has been constructed by the system, at a cost of several million dollars, to divert 46,000 acre-feet annually from tributaries of Colorado River and deliver the same, via a tunnel through the Continental Divide at Independence Pass, into Twin Lakes reservoirs and thence

via the river and Colorado Canal to the lands of the system (Colorado Exhibit 194, Tr. Vol. XXXVII, p. 6513; App. "B," p. 36-41).

The fact that the above mentioned canals along the Arkansas River in Colorado, constructed initially during the years 1884 to 1893, shortly thereafter began the construction of reservoirs in order to supply their lands then under irrigation with adequate, or more nearly adequate, quantities of water, indicates that the river did not at that time furnish dependable, seasonal water supplies, and that, instead, the water supplies beginning with 1889 and thereafter were inadequate in amount and non-dependable in character (Tr. p. 3426, Vol. XX).

Shortages are experienced under all main river ditches with frequencies that increase with the junior dates of their appropriations.

COLORADO DIVERSIONS AND STATE LINE FLOW.

Stream flows crossing the Stateline from Colorado into Kansas have increased in their usable amounts. Waters recovered by some of the drains constructed in Colorado are delivered directly to Kansas and the ditches in that state. All the discharges of the Holly drain, which flow continuously at rates averaging about 25,000 acre-feet annually (Colorado Exhibit 129, Tr. Vol. XIX, p. 3244; Kansas Exhibit 17, Tr. Vol. IX, p. 1440; etc.), are delivered to Kansas crossing the Stateline either in the Frontier ditch or in the river channel or both.

Throughout the period since 1907, during which the Stateline flows from Colorado into Kansas have been measured and recorded, there has been no diminution in the quantities of water usable for irrigation in Kansas and used by ditches in that state. The quantities of water diverted by the Kansas ditches (Colorado Exhibit 213—Vol. XXXVII p. 6653; App. "B," p. 65) (Table 30, p. 127, appendix "A") though varying from season to season, and year to year, in accordance with natural climatic con-

ditions, have gradually increased in amount. From records of the diversions made from the Arkansas River by ditches in Colorado, which records begin with the year 1904, such increases in the quantities diverted as have been recorded are attributable to the inclusion, as part of the diversion records, of increasing amounts of return flows, being waters which once recorded when first diverted are again recorded as re-diverted.

Witness Meeker, in behalf of Kansas, undertook an elaborate series of calculations and estimations, termed an analytical study (Kansas Exhibits 24 to 70, vols. IX-X, pp. 1462-1569). This so-called analytical study purports to disclose the total original water production in Colorado, year by year from 1895 to 1930; the Stateline flows each year from 1895 to 1907 (prior to the years of measurement thereof), based on estimates made from observations at other stations, some hundreds of miles away; and the quantities of water consumed in Colorado, based on calculations of main river consumption during 1912 to 1930, with estimates based on assumed unit rates in upriver and tributary areas, and on a different method of estimation, for the years 1895 to 1911, in which all the conclusions of that period were derived from initially assumed unit rates. Comparing the results of the earlier period, based on one method of estimation, with the results of the later period, based on another and different method of estimation, the witness Meeker says, that Colorado has increased its consumption of stream flows and its depletion of water supplies by 300,000 acre-feet (Tr. p. 1566, vol. X).

Colorado witness R. J. Tipton (Colorado Exhibits 83 to 122, vol. XIX, pp. 3117-3217), testified that, from the records of stream flows, diversions and return flows, including the records of diversions made from the Arkansas River by ditches in Colorado from 1904 to 1911, that Colorado's depletions of the main river water supplies have not increased during the period 1904 to 1932.

Kansas witness Geo. S. Knapp, testified, in effect, that regardless of the evidence disclosed by records of

Stateline flows and of ditch diversions in Colorado and their effects on stream flows and water supplies, the increased irrigated acreages in Colorado indicate that depletion to the extent of 400,000 acre-feet has occurred, because each acre of irrigated land constitutes a fixed and invariable burden on the water supply (Tr. pp. 5220, Vol. XXIX).

Colorado witness C. L. Patterson, testified that the quantities of water diverted by certain major ditches in Colorado had remained substantially constant over periods of three and four decades, during which the acreages irrigated thereunder had increased and the return flows therefrom had increased (Tr. pp. 3667-3669, vol. XXII). That although the quantities of water consumed and returned to the atmosphere by evaporation and transpiration may be a fairly constant quantity under given climatic conditions and uniform irrigation practices, the quantities of water withheld from the stream, by being retained in underground storage, are large during early years and decades of diversion operations, and decline thereafter; and as return flows increase in amount the total quantities of water consumed and withheld from the stream, and the unit rates of consumption per acre irrigated, instead of being constant, actually and in fact decline in amount with age (Tr. pp. 3680-3683, vol. XXII).

Since the Stateline flows as recorded during 1908 to 1930 averaged, in round numbers, 300,000 acre-feet (Tr. pp. 6509-6542, vol. XXXVII, Colo. Ex. 193), then the Stateline flows during previous years, if they have since been depleted 300,000 or 400,000 acre-feet as alleged, must have averaged 600,000 or 700,000 acre-feet per year. If such Stateline flows actually existed, as alleged, a large share thereof, approximating one-half of the total, must have come from the Colorado mountains. Total original water production in plains areas, estimated by the witness Meeker at 340,000 acre-feet (Kansas Exhibit 35, Tr. vol. IX, p. 1490), when measured at the Stateline, to allow for its diminution by natural channel conveyance losses, would

not exceed and might be substantially less than 300,600 acre-feet. Since plains runoff accounts for half, or less, of the claimed total Stateline flows, mountain runoff must have contributed the remaining half or more. Mountain runoff is perennial, and, by the witness Meeker, is designated as dependable. If the claims advanced by the witnesses Meeker and Knapp be correct, that the Stateline flow from Colorado into Kansas during the years prior to 1908, averaged 600,000 or 700,000 acre-feet annually, they must have consisted of fluctuating amounts of plains floods, making up about half the total, and of more or less constant amounts, year by year, of perennial and dependable stream flows from the Colorado mountains making up the other half, or say 300,000 acre-feet annually as claimed in Kansas Exhibit 99, (Tr. vol. X, p. 1750).

The Meeker study purports to cover the period of 36 years from 1895 to 1930, and, by comparisons between the average values of early and recent periods, to disclose the changes which have occurred in the consumption of stream flows and depletion of water supplies in Colorado. Since the methods of arriving at the figures were not uniform throughout the period, it becomes necessary, in order to evaluate the comparative results, to consider both the methods and the probable accuracy of the calculations, estimates and assumptions.

The Stateline flow values for the years after 1907 were measured, whereas those for prior years were deduced, i.e., estimated from stream flows recorded at other stations, some of which, as at Hutchinson, were long distances away (Tr. p. 3642, vol. XXII). Estimated Stateline flows during the first 12 years of the period, from 1895 to 1906, averaged 421,700 acre-feet per year, and recorded Stateline flows during the last 12 years of the period, from 1919 to 1930, averaged 349,200 acre-feet per year (Kansas Exhibit 62, Tr. vol. IX, p. 1519). The indicated diminution was 72,500 acre-feet. This indicated decline may be attributable to the uncertainty and liberality of the estimates for the earlier years. Each of the twelve

year periods contain two extra large or unusual years. The value estimated for 1900 was 980,000 acre-feet and for 1905 was 950,000 acre-feet, which values are extraordinary and questionable, since they equal or exceed the recorded quantities of 960,000 acre-feet in 1921, the year of the greatest flood of record, and of 820,000 acre-feet in 1923, which was the wettest year of record to the time of the so-called analytical study (Kansas Exhibit 62, Tr. vol. IX, p. 1519).

The Meeker so-called analytical study, with respect to the question of alleged increased consumption and depletion in Colorado, presents an important discrepancy found in the methods and the initial assumptions under which the total consumption of water, in the early and recent periods, was calculated or estimated and thereafter compared. Results for the period 1912 to 1930 were in part estimated and in part calculated from stream flow, diversion, and return flow records. Consumption of water in all upriver and tributary areas in Colorado was estimated by assuming the unit rates of consumptive use per acre irrigated (Tr. p. 3643, vol. XXII), and these estimated or assumed results were then added to the main river values to make up the alleged total consumption. Along the main Arkansas River from Canon City to the Stateline, the results are said to be calculated by the inflow-outflow method, under which the excess of inflow over outflow values was designated the amount consumed (Tr. p. 3642, vol. XXII). The tributary inflows were largely unmeasured and must be estimated or assumed. If the tributary inflows be estimated too high, then the resulting answers as to total water production and consumption would be too high (Tr. p. 3648, vol. XXII). Terming the results for 1912 to 1930 as calculated, these are compared with results for the period 1895-1911, arrived at by a wholly different process of estimation wherein the unit rates of consumptive use per acre irrigated were arbitrarily assumed.

The said calculated results for the main river section, Canon City to Stateline, summarized from Kansas Exhibit 56, (Tr. vol. IX, p. 1513), in the average year of the periods shown, were as follows:

Table 3b

Period of Years	Consumption (Acre-Feet)	Irrigated (Acres)	Consumption Per Acre
1912-15	906,250	326,500	2.78
1916-20	834,400	345,800	2.41
1921-25	750,600	333,600	2.25
1926-30	766,000	352,600	2.17

Comparing the period 1912-15 with 1926-30, there was an increase of 26,000 acres in the area irrigated, accompanied by a decline of 140,000 acre-feet in the total quantity of water consumed and thus withheld from the Arkansas River and from Kansas. There was a consistent decline in the amount of water consumed per acre irrigated, indicating that of the quantities of water diverted from the Arkansas River for direct application and storage purposes, increasing portions thereof were returned to the river unconsumed, and diminishing portions thereof were consumed or withheld (Tr. p. 3657, vol. XXII).

Having calculated the water consumption along the main Arkansas River, Canon City to Holly, as above outlined, Mr. Meeker added these calculated values (Col. 2 of Kansas Exhibit 59, Tr. vol. IX, p. 1516) to the estimated consumption in mountain valleys above Canon City, in which both the upriver and tributary unit rates were wholly and arbitrarily assumed, thus arriving at the total consumption in Colorado. These total values are reproduced in Kansas Exhibit 60, (Tr. vol. IX, p. 1517) and, after adjustments for storage in and release of water from mountain reservoirs, are divided by the irrigated areas, to arrive at unit rates of consumptive use in Colorado, as follows:

Table 3c

Period of Years	Consumption (Acre-Feet)	Irrigated (Acres)	Consumption Per Acre
1912-15	1,147,000	485,000	2.35
1916-20	1,080,000	516,400	2.10
1921-25	1,018,000	517,400	1.95
1926-30	1,048,000	541,000	1.95

Comparing the first and last periods, an increase of 56,000 acres occurred in the irrigated area, accompanied by a decline of 99,000 acre-feet in the quantities of water consumed.

The Meeker claim of an increased depletion of 300,000 acre-feet is based solely upon what he terms computed values (Kansas Exhibit 61, Tr. vol. IX, p. 1518) for the period prior to 1912. They were computed by multiplying the number of acres irrigated by what he terms "appropriate consumptive use values," which values were arbitrarily assumed. He says they were "deduced from actual values 1912 to 1930, modified by character of yearly water supply, reservoir storage and related matters."

With respect to reservoir operations Mr. Meeker asserts (Tr. p. 3659, vol. XXII), that operating storage was limited to 240,000 acre-feet at the time of the original interstate case, and that subsequently 380,000 acre-feet have been added. At Tr. pp. 3659-3664, vol. XXII, this is shown to be erroneous and his allowances based thereon must also be in error. For example, the Great Plains reservoirs were constructed to a total (available and unavailable) capacity of 265,552 acre-feet, beginning August 1, 1896. They were completed, the unavailable capacity had been filled, and water was being released and used in 1899. The capture during 1898 and 1899, together with the capture of 114,148 acre-feet in 1900, filled the reservoirs to their capacity (Tr. pp. 3660, vol. XXII). There are nine major reservoirs in Colorado with construction priorities senior to the Great Plains. Total decreed capacity of all major reservoirs constructed to date is 697,347 acre-feet (Colo-

rado Exhibit 157, Tr. vol. XXII, p. 3661). Those having priorities in 1907 and prior thereto aggregate 535,110 acre-feet, or 88 percent of the total. Of these early reservoirs 490,016 acre-feet of capacity attaches to the main river. Reservoirs constructed since 1907 have aggregate capacities of 72,237 acre-feet, which in part represents subsequent enlargements of previously constructed reservoirs. In the average year the Colorado reservoirs capture 21.5 percent of their decreed capacities, or about 130,000 acre-feet annually. As indicated by operations of the Great Plains Reservoirs, the quantities captured and stored were no greater after 1912 than before, the record thereof showing (Tr. p. 3660, vol. XXII):

Table 3d

Period of Years	Avge. A. F. Stored
1899 to 1908	62,408
1909 to 1918	54,024
1919 to 1928	54,113

Diversions made during early years of irrigation project operations are commonly large per acre irrigated, due, among other things, to dryness or emptiness of sub-soil and underground strata (Tr. p. 3687, vol. XXII). For example, the records of diversions from the Arkansas River made by the Amity Canal, the acreages irrigated, and the rates of diversion per acre, were as follows (Tr. pp. 3667-3669, vol. XXII):

Table 3e

Period Of Years	Diversions A.F./Year	Acreages Irrigated	Diversions Per Acre
1894-1903	75,186	10,398	7.2
1904-1913	81,549	26,550	3.4
1914-1923	87,184	33,825	2.6
1924-1930	81,453	36,921	2.2

Much of the total acreage expansion along the Arkansas River, since the original *Kansas v. Colorado* case, has occurred under the Amity and Fort Lyon irrigation systems, whose diversions from the river for storage and irrigation purposes, are made via three canals, namely, the Ft. Lyon Storage Canal, Ft. Lyon Canal and Amity Canal. Aggregate diversions of the three canals were 316,895 acre-feet per year during 1904 to 1913; 375,093 acre-feet per year during 1914 to 1923 (which included the four large water years of 1914, 1915, 1921 and 1923); and were 307,000 acre-feet per year during 1924 to 1933 (Tr. p. 3690, vol. XXII). During the period the river gains due to return seepage along the stretch from La Junta to Holly, adjoining the lands of these systems, increased from an average of 58,500 acre-feet per year during 1897 to 1904, to an average of 141,700 acre-feet per year during 1922 to 1925 (Tr. pp. 3691; vol. XXII). With diversions fairly constant, and with increased return flows, the increased acreages under the Ft. Lyon and Amity Systems have not depleted the water supplies of the river (Tr. p. 3692, vol. XXII).

The amount of water consumed in Colorado and thus withheld from the Arkansas River and from Kansas, is measured, not by the acreage to which the water may be applied, but by the quantities of water diverted from the river that are not returned thereto. Records of the diversions from the Arkansas River by ditches in Colorado are available for the period from 1904 to date. Such records were summarized by the witness Meeker for all ditches from Canon City to the Stateline for the period from 1912 to 1930, as shown in Kansas Exhibit 96, (Tr. vol. X, p 1744). Although he submitted information as to the diversions of some ditches at Canon City for years prior to 1912, he elected to ignore the records of ditches from Pueblo to Stateline for the period 1904 to 1911, to abandon the method of analytical study such as employed for the period 1912 to 1930, and, in lieu thereof, to estimate the consumption based on arbitrarily assumed rates. Diversion records of the same Canon City to Stateline ditches, summarized in Kansas Exhibit 96 for the period 1912 to 1930, appear

in Colorado Exhibit 194, (Tr. vol. XXXVII, p 6513; App. "B," p. 36-41) for the period 1931 to 1940. Aggregate diversions in acre-feet per year, averaged for the periods shown in Kansas Exhibit 96, and for similar five year periods from Colorado Exhibit 194, were as follows:

Table 4

Average Annual Diversions from Arkansas River Ditches in Colorado—Canon City to Stateline. (Values in Acre-Feet).

Period of Years	Average Annual Diversions	
1912 to 1915	1,145,000	
1916 to 1920	1,122,000	
1912 to 1920		1,132,000
1921 to 1925	1,064,000	
1926 to 1930	1,116,000	
1921 to 1930		1,090,000
1931 to 1935	822,000	
1936 to 1940	932,000	
1931 to 1940		877,000

The said diversions, Canon City to Stateline, include all quantities diverted above and by-passed around the stream-gaging station at Canon City; all waters imported from other stream systems; all waters released from upstream reservoirs; all waters diverted for irrigation, municipal, industrial and other beneficial purposes; all waters diverted for direct application and for storage purposes, including waters diverted but unapplied to lands and wasted back to river (estimated in Kansas Exhibit 96 to average 110,000 acre-feet annually); and all waters which, measured once as diverted, are returned unconsumed and again rediverted and remeasured, and again included in said totals.

Diversion records are shown in Colorado Exhibits 91 to 97, (Tr. vol. XIX, p. 3153), for the years 1904 to 1911; in Kansas Exhibits 7(a) to 7(s) (Vol. IX, p. 1345) for the years 1912 to 1931; in Colorado Exhibit 152 (Tr. vol. XXI,

p. 3593) for the year 1932; in Colorado Exhibits 98 and 98(a) (Tr. vol. XIX, p. 3161) the records are summarized for the period 1904 to 1932; and for subsequent years may be derived from data summarized in Colorado Exhibit 194 (Tr. Vol. XXXVII, p. 6513; App. "B," p. 36-41). All the said ditch diversion records were originally reported and published by the same agency, *i. e.*, the State of Colorado, Irrigation Division Engineer, in co-operation with the Arkansas Valley Ditch Association. Average annual diversions of said ditches during periods prior and subsequent to 1912, together with the river gains due to return flows, and the indicated depletions of the original water supplies, are shown in the following:

Table 5.

Average Annual Diversions, Returns and Depletions
Arkansas River—Pueblo to Stateline.
(Values in Acre-Feet)

Periods	Diversions (a)	Returns (b)	Depletions (c)
1904-1911	906,000	120,000	786,000
1912-1920	984,000	186,000	798,000
1921-1930	987,000	256,000	731,000
1931-1940	787,000		

(a) Data from Colo. Ex. 91 to 98; 102; 194; (App. "B," p. 36-41; Kans. Ex. 7(a) to 7(s). Aggregate diversions all ditches below Pueblo, plus Bessemer, Arkansas Valley and miscellaneous ditches above Pueblo.

(b) Net river gains due to return seepage, Pueblo to Stateline, from testimony of C. L. Patterson (Tr. pp. 883-885, vol. VI); Kans. Ex. 32 (Tr. vol. IX, p. 1485, App. "B,", p. 72) used 130,000 for 1910; 186,000 for 1912 to 1920; and 240,000 for 1921 to 1930.

(c) Depletions are differences, i. e., diversions minus returns,—the indicated depletions exceed actual depletions by the quantities diverted and returned unconsumed, but not classified as return seepage.

Acreages irrigated along the Arkansas River between Pueblo and the Stateline, in Water Districts 14, 17, and 67, increased 53,230 acres, from an average of 299,660 acres during the period 1904 to 1911 to 352,890 acres per year during 1921 to 1930 (Kansas Exhibit 51, Tr. vol. IX, p. 1507).

Information concerning acreages irrigated in upriver (above Canon City) and tributary areas is available, but there are no records of diversions and returns from which to ascertain the depletions incident thereto. Admittedly, the consumptive use of water per acre irrigated is substantially less in upriver and tributary areas than along the lower main river, where from 63 to 70 percent of the total irrigated areas in the Arkansas River basin in Colorado are located. Having determined the effects of irrigation and increased acreages along the lower main river, the question arises as to the less extensive and scattered areas upstream and on tributaries. In all Water Districts of Irrigation Division No. 2, other than districts 14, 17, and 67 (main river districts), there was an increase of 54,880 acres, from an average of 121,458 acres during 1904 to 1911, to an average of 176,338 acres during 1921 to 1930 (Kansas Exhibit 51, Tr. vol. IX, p. 1507).

The natural precipitation, runoff, stream flows and water supplies of the 1880 decade were abnormal or above average. (Tr. pp. 3698-3700, vol. XXII). At that time, and during the first few years of the 1880 decade, large canals were constructed along the Arkansas River in Colorado, and the practice of irrigation began in Kansas. All these recently constructed enterprises in both states found themselves in great difficulty when the drouth of 1889-1894 occurred, giving rise to subnormal or below average stream flows and water supplies. The Kansas ditches became involved in receiverships, about 1894, and thereafter until about 1905 were more or less abandoned and largely useless, as determined in the 1907 decree in *Kansas v. Colorado*. Then from 1905 to 1910 they were rehabilitated and the period of development of underflow and underground waters began in Western Kansas.

The United States Census Bureau reported that in 1909 there were 464,236 irrigated acres in the Arkansas basin in Colorado, and in 1939 the figure was 469,168 (Colorado Exhibit 206, vol. XXXVII, p. 6622) The consumption of water in Colorado has declined according to evidence presented by Kansas itself. Kansas Exhibit 56

(Tr. p. 1513, vol. IX) as summarized in Table 36, p. 77, Appendix "A," shows a decline in water consumption for the main river section Canon City to Stateline, from 906,250 acre-feet as the annual average for the 1912-1915 period to 766,000 for the 1926-1930 period. A further decline since 1930 appears in Colorado Exhibit 194, page 3 (App. "B," p. 38), which shows that the ditch diversions along the main river have been less since 1930 than the average prior to 1930 (Tr. p. 6513, vol. XXXVII).

RETURN FLOWS.

At first, all the waters diverted by ditches and applied to lands were withheld from the stream. One portion thereof was consumed by evaporation and transpiration, and being returned to the atmosphere, was withheld from the stream from whence diverted. The second and remaining portion percolated downward through the soils, subsoils and underground formations where, being retained in such underground storage, it was withheld from the stream. With continued diversions and applications from year to year, and with continued contributions to the underground waters, their surface levels were elevated until, in time, gradients toward the river channels were established, in lieu of the original and natural conditions under which the surface flows disappeared into the absorbent sands and gravels of the stream valleys. As the water tables continued to increase in elevation, with increasing gradients toward the river, less of the unconsumed waters percolating downward from ditches and irrigated lands were retained in ground storage, and greater portions thereof seeped back or returned to the stream. Thus, in time, what had previously been a losing river was converted into a gaining stream along its stretches where the return flow quantities attained volumes in excess of natural conveyance losses (Tr. pp. 3686-87, vol. XXII).

In the Arkansas River valley the first official measurements were made during the years 1897 to 1904. These disclosed that the river gained in volume, between Pueblo and the Stateline, by an average of 106,000 acre-feet per

year, (Tr. p. 883, vol. VI). The measured river gains represent the net effects of the return flow waters. Actual volumes of the return flows reaching the river necessarily exceeded the measured effects thereof in causing river gains, by whatever natural channel losses prevailed along the river section. Such channel natural conveyance losses, between Pueblo and the Kansas Stateline, average 126,300 acre-feet annually (Tr. p. 3682, vol. XXII):

Similarily conducted measurements made during the years 1922 to 1925 disclosed that river gains due to return seepage had increased by 150,000 acre-feet annually, and were then of a magnitude of 256,000 acre-feet per year (Tr. p. 884, Vol. VI). The net river gains of the 1922 to 1925 period, averaging 256,000 acre-feet annually, approximate 40 percent of the total flow of the Arkansas River as it emerges from the mountains at Canon City (Tr. p. 3427, Vol. XX).

In the stretch of river from Lamar to the Stateline, adjoining the lands irrigated under the Amity Canal, the river gain due to return flows increased from 20,000 acre-feet per year during 1897 to 1904, to 50,000 acre-feet during 1922 to 1925. This gain of 30,000 acre-feet has largely accrued to the benefit of the Kansas ditches (Tr. p. 3669, vol. XXII).

By reason of the said increase in return flow quantities, amounting to 150,000 acre-feet between the periods of 1897 to 1904 and 1922 to 1925, and by reason of other factors connected with irrigation development, increased areas of land were irrigated in the counties of Pueblo, Crowley, Otero, Bent and Prowers in Colorado, where such increased return flows developed and became available for additional diversions and utilization. These increased areas coming under irrigation were located under enterprises previously constructed—no new ditches for direct irrigation have been initiated after 1893 along the Arkansas River in said counties. Reservoirs were constructed which conserve, and made available for additional use, waters which previously were unused and wasted and which served no beneficial purpose in either state, and such

reservoirs were important factors in connection with the increased diversions and areas of land irrigated.

In addition, from the time of the original interstate litigation to the present, increasing quantities of water were imported to the Arkansas River from other streams systems. Such imported quantities increased from substantially zero at the time of the original *Kansas v. Colorado* case, to approximately 60,000 acre-feet in the season of 1938 (Colorado Exhibit 194, Tr. Vol. XXXVII, p. 6513; App. "B," pp. 36-41). These imported waters are largely diverted in Pueblo County and are used in Pueblo, Crowley and Otero counties.

Conservation of water resources in Colorado has been aided and promoted by the construction of artificial drainage as and when needed. Water recovery by drains (Colorado Exhibits 124-129, Tr. Vol. XIX, p. 3244) added to the return flows and usable water supplies, by eliminating the evaporation losses from seeped or water-logged lands.

As irrigation is practiced year after year the return flows are increased. The unchallenged Colorado evidence is that return flows had increased to an extent such that river gains from Pueblo to the Stateline averaged 106,000 acre-feet annually during 1897-1904, (Tr. p. 883, Vol. VI) and thereafter a further increase of 150,000 acre-feet occurred, until the river gains due to return seepage during 1922-1925 averaged 256,000 acre-feet annually, (Tr. p. 884, Vol. VI).

Factors contributing to an increase in both the irrigated acreage and the Stateline flows are (1) the importation of water from other stream systems amounting to approximately 60,000 acre-feet in 1938, (Colo. Ex. 194, Tr. pp. 6513, Vol. XXXVII; App. "B," pp. 36-41) (2) the construction of artificial drainage, (Colo. Exhibits 124-129, Tr. pp. 3244, Vol. XIX) and (3) improvements in the duty of water resulting from increased efficiency in the conveyance, application and use of water (Tr. p. 3683, Vol. XXII).

Reservoirs store winter and flood waters that are not used for direct irrigation. If such water were not stored, it would pass out of the basin unused. Evaporation losses from storage reservoirs are unimportant in this case because they represent the loss of water which would be lost for irrigation in any event. In spite of these evaporation losses the storage reservoirs, by conserving water that would otherwise be unavailable, increase the usable suplies.

CONDITIONS IN KANSAS SINCE THE 1907 DECISION

IRRIGATED ACREAGE AND KANSAS DIVERSIONS.

Census figures show that in 1909 there were irrigated in the Arkansas River basin in Kansas 35,357 acres, and, in 1934, 94,064 acres; and in the three counties of Hamilton, Kearney and Finney the increase was from 34,819 acres in 1909 to 56,341 acres in 1939 (see Table 7, p. 90, Appendix "A").

Kansas ditch diversions have increased from an average of 59,200 acre-feet annually for the 1908-1913 period to 99,100 annually for the 1933-1938 period (Colorado Exhibit 213, Vol. XXXVII, p. 6653; App. "B," p. 65). Table 30, p. 127, Appendix "A." The amount of diversions has steadily risen in proportion to what Kansas itself has set up as index flows (Table 5a, p. 88, Appendix "A." Since 1907, the Kansas diversions have steadily increased from the standpoint not only of their actual amount but also of their relationship to what Kansas calls the dependable flow of the river. The index flows are taken from a Kansas exhibit. The diversions are of the Kansas ditches. The computations disclose that for the 1908-1913 period the diversions represented 8.9% of the index, or what Kansas calls the dependable, flow. For the years 1933-1938, the percentage is 18.3. The average for the entire 31-year period is 12.6%.

The flows at the Index Stations provided for in the Master's Report (pp. 12, 16, 21) and their relation to Kansas ditch diversions are as follows:

TABLE 5a

RELATIONS BETWEEN INDEX FLOWS AND KANSAS DIVERSIONS

(Compiled from Kans. Ex. 134, Tr. Vol. XXXIX, p. 7019 App. "B," p. 73 and Colo. Ex. 213, Tr. Vol. XXXVII, p. 6653, App. "B," p. 65)

Six Year Periods	Average Annual Index Flows (Acre-Feet)	(% Avg.)	Average Annual Diversions of Ditches in Kansas (Acre-Feet)	(% Avg.)	(% Index)
1908-13	667,510	99.6	59,200	69.7	8.9
1909-14	741,910	110.7	67,700	79.7	9.1
1910-15	719,100	107.3	69,700	82.1	9.7
1911-16	736,160	109.8	73,900	87.0	10.0
1912-17	734,170	109.5	73,600	86.7	10.0
1913-18	726,750	108.4	72,600	85.5	10.0
1914-19	764,270	114.0	84,300	99.3	11.0
1915-20	736,530	109.9	86,900	102.4	11.8
1916-21	750,220	111.9	81,200	95.6	10.8
1917-22	723,360	107.9	77,000	90.7	10.6
1918-23	783,350	116.9	87,300	102.8	11.1
1919-24	784,820	117.1	85,100	100.2	10.9
1920-25	747,270	111.5	88,200	103.9	11.8
1921-26	726,050	108.3	82,600	97.3	11.4
1922-27	726,560	108.4	92,100	108.5	12.7
1923-28	743,000	110.8	97,000	114.3	13.1
1924-29	687,630	102.6	98,100	115.5	14.3
1925-30	673,460	100.5	108,200	127.4	16.1
1926-31	654,070	97.6	99,000	116.6	15.1
1927-32	638,810	95.3	94,900	111.9	14.9
1928-33	590,550	88.1	92,000	108.5	15.6
1929-34	533,120	79.5	85,600	100.9	16.1
1930-35	503,830	75.2	82,000	96.7	16.3
1931-36	512,760	76.5	82,600	97.4	16.2
1932-37	527,350	78.7	84,000	99.0	16.0
1933-38	540,350	80.6	99,100	116.8	18.3
1908-38	670,380	100.	84,900	100.	12.6

Index Flows are the sum of Arkansas River at Canon City, adjusted to exclude importations and to include quantities by-passed around the station, to indicate mountain runoff, plus contributions of Purgatoire River to Arkansas River, to indicate plains runoff (Per Kans. Ex. 134, App. "B," p. 73.

Diversions of Kansas ditches per Colo. Ex. 213 (App. "B," p. 65).

Official information concerning irrigation has been included in all decennial reports of the U. S. Census Bureau, beginning with that of 1890, to date, each relating to the preceding crop season. Irrigation was the subject of a Special Census conducted by that agency in 1902, at the time of the adoption by Congress of legislation commonly referred to as the Reclamation Act. A summary of data from U. S. Census Reports, appearing in the record among other places, as Kansas Exhibits 51, 52, (Tr. Vol. IX, p. 157); Colorado Exhibits 196, (Tr. Vol. XXXVII, p. 6551, App. "B," 47-51), 206 (Tr. Vol. XXXVII, p. 6628); and as testimony at pp. 1819-23, Vol. XI, 2356, Vol. XIV, 5583, Vol. XXXI, 5608, Vol. XXXI, shows:

There are 31 counties in the Western division of Kansas, all of which are subject to the less-humid or more arid climate of that region. Of these, 17 counties, largely in Northwestern Kansas, are wholly outside the basin of the Arkansas River, and in general are favored by somewhat greater amounts of precipitation than the counties in the southwestern portion of the state, wherein the remaining 14 counties are located wholly or in part within the basin, and five of these, namely, Hamilton, Kearney, Finney, Gray and Ford, are situated on and crossed by the channel of the river.

A comparison of irrigation in Kansas and in Colorado, is shown by the following statistics from the 1930 census (see Tr. pp. 3338 *et seq*, Vol. XX).

TABLE 6

	Kansas Acres	Colorado Acres
Total Land Area	52,335,360	66,341,120
Land in Farms	46,975,054	28,876,171
Cropland	26,535,054	8,448,684
Harvested Crops	24,308,361	6,750,308
Irrigated Land	71,290	3,393,619
Irrigable Acreages	95,719	4,528,251

The testimony of Mr. Patterson is (Tr. p. 3346, Vol. XX):

> "The only logical conclusion to be drawn from such statistical records is that irrigation in Kansas plays a very minor part as compared to the major part which irrigation plays in the agriculture of the Arkansas River Basin in Colorado."

TABLE 7

Irrigated Acreages in Arkansas River Basin
In Colorado and Kansas

		Data for State of Kansas			
Year	Basin in Colorado	Entire State	Ark. R. Basin (a)	Five Counties (b)	Three Counties (c)
1889	144,858	20,818	17,821	17,572	15,499
1899	281,592	23,620	19,483	18,570	17,924
1902	300,115	28,922	.....	.....	.....
1909	464,236	37,479	35,357	34,879	34,819
1919	(641,476)(d) 516,213	47,312	46,539	41,485	(40,660)(e) 52,949
1929	557,933	71,290	68,781	60,897	60,072 (f)
1939	469,168	99,980	94,064	64,104	56,341

(a) Data for Arkansas River basin in Kansas excludes areas in Cimarron River valley, but includes areas in tributaries entering below Garden City, as Pawnee Creek, and includes areas irrigated from ground waters, as Scott County and elsewhere.
(b) Five Counties are Hamilton, Kearney, Finney, Gray and Ford.
(c) Three Counties are Hamilton, Kearney and Finney.
(d) Per Colorado Exhibit 206: "Believed too large by reason of inclusion of lands under Carey Act and other projects for which irrigation works were not completed,"—Figure below from Kansas Exhibit 51, i.e., District Water Commissioner Reports.
(e) Kansas witness Knapp (T., p. 2355, Vol. XIV) contends figure is too low,—suggests substitution of figure below, from Kansas Exhibit 115, Vol. XIV, p. 2355.
(f) 46,837 acres irrigated with river water, 13,235 acres served by wells and pumps.

Information concerning the extent of irrigated acreages in the Arkansas River basin in Colorado is also available, year by year, from reports of District Water Commissioners, summaries of which appear in the record as Kansas Exhibit 51, (Tr. Vol. IX, p. 1507,) to and including the year 1930, and as Colorado Exhibit 206, (Tr. Vol. XXXVII, p. 6622,) for the years 1931 to 1940, as shown in the following:

TABLE 8

Irrigated Acreages in Arkansas River Basin in Colorado
As Reported by District Water Commissioners
Compiled From
Kansas Exhibit 51, Years 1896-1930
Colorado Exhibit 206, Years 1931-1940

Years	Acres	5-Yr. Avge	Years	Acres	5-Yr. Avge
1896	380,637		1921	518,947	
97	348,199		22	496,366	
98	331,336		23	523,105	
99	324,903		24	543,779	
1900	349,729	347,000	1925	505,448	518,000
1901	354,043		1926	544,868	
02	312,484		27	524,033	
03	337,050		28	536,701	
04	368,109		29	544,214	
1905	387,731	352,000	1930	554,814	541,000
1906	382,827		1931	535,377	
07	439,515		32	500,241	
08	466,457		33	496,373	
09	427,098		34	416,373	
1910	415,936	426,000	1935	469,859	484,000
1911	481,261		1936	493,360	
12	483,125		37	488,886	
13	464,078		38	486,686	
14	491,343		39	465,672	
1915	504,426	485,000	1940	455,159	478,000
1916	499,731				
17	506,317				
18	515,839				
19	516,213				
1920	544,458	517,000			

TABLE 9

Interstate Relations per Irrigated Acreages (Computed)

Census Years	Basin Totals	Colorado Portion Acres	Colorado Portion Percents	Kansas Portion Acres	Kansas Portion Percents
1889	160,357	144,858	90.3	15,499	9.7
1899	299,516	281,592	94.0	17,924	6.0
1902	324,650	300,115	92.4	24,535*	7.6*
1909	499,055	464,236	93.0	34,819	7.0
1919**	569,162	516,213	90.7	52,949	9.3
1929	618,005	557,933	90.3	60,072	9.7
1939	525,509	469,168	89.3	56,341	10.7

*Figure for 1902 covers entire basin in Kansas, and includes areas in Cimarron River Valley and areas along main river and tributaries in Kansas east of Finney County.
**Figures for 1919 from sources other than United States Census Bureau.

CROP PRODUCTION IN KANSAS

TABLE 10

Acres of Field Crops Harvested in Kansas by Divisions (From K.S.B.A. Reports: Colo. Ex. 53 App. "B," p. 8). (Vol. XVII, p. 2924)

Year	State Totals	Divisions of Kansas Eastern	Central	Western
1881	8,656,403	4,404,709	4,096,743	154,951
1885	8,765,866	4,371,783	4,213,876	180,207
1888	10,088,083	4,831,581	4,350,209	906,293
1890	8,127,011	4,035,643	3,364,542	716,826
1895	16,720,741	6,235,740	8,687,883	1,797,118
1900	16,219,416	6,142,096	8,322,523	1,754,797
1905	17,558,740	6,014,521	9,212,143	2,332,076
1910	19,164,643	5,667,339	9,719,277	3,768,027
1915	18,201,971	5,160,395	9,389,537	3,652,039
1920	21,759,497	6,284,868	10,652,051	4,822,578
1925	21,342,760	5,485,971	10,228,529	5,628,260
1930	23,567,658	5,416,559	11,000,246	7,150,853

The values of agricultural products in Kansas, shown annually for the period 1881 to 1930 in Colorado Exhibit 64, (Tr. Vol. XVII, p. 3967, App. "B," p. 11) may be summarized by decade averages as follows:

TABLE 11

Average Annual Values of Agricultural Products

Decade	All Products	Field Crops*	Other Products**
1881-1890	$131,756,300	$ 84,439,400	$ 47,316,900
1891-1900	146,108,400	87,328,000	58,780,400
1901-1910	248,597,200	158,754,500	89,842,700
1911-1920	448,500,500	316,925,700	131,574,800
1921-1931	451,435,000	291,282,500	160,152,500

*Field crops include wheat, corn, oats, rye, barley, potatoes, cowpeas, soybeans, flax, cotton, broom corn, millet, sugar beets, pinto beans, sorghums, milo, kaffir, feterita, sudan grass, alfalfa, timothy and clover, but not prairie grass.

**Other products include livestock, poultry, dairy, horticultural and other products except field crops.

TABLE 12

Values of Field Crops in Kansas by Divisions
(From K.S.B.A. Reports: Colo. Ex. 65, Tr. Vol. XVII, p. 2974, App. "B," p. 12)

Years and Decade Avgs.	Whole State	Divisions of Kansas Eastern	Central	Western
1881	$ 91,928,376	$ 47,304,270	$ 43,478,240	$ 1,145,886
1885	73,877,167	36,717,180	35,387,150	1,772,837
1888	96,113,900	49,889,490	38,512,300	7,712,110
1890	70,148,683	35,953,000	29,785,730	4,409,953
81-90*	85,576,000	42,582,000	39,557,000	3,437,000
1895	74,109,796	39,420,980	29,080,750	5,608,066
1900	113,285,386	48,274,909	57,829,850	8,180,627
91-00*	87,406,000	41,465,000	39,965,000	5,976,000
1905	158,589,054	56,748,777	81,880,702	19,959,575
1910	191,323,126	61,695,926	102,524,540	27,102,660
01-10*	158,754,000	54,828,000	85,884,000	18,042,000
1915	243,449,493	69,747,598	127,270,810	46,431,085
1920	520,696,841	158,318,571	247,960,620	114,417,630
11-20*	316,926,000	106,724,000	158,682,000	51,520,000
1925	274,781,645	101,040,235	118,533,010	55,208,400
1930	222,811,300	58,196,150	103,001,030	61,614,120
21-30*	291,283,000	86,219,000	141,382,000	63,682,000

*Values are ten-year averages for decades shown.

TABLE 13

Acres of Field Crops in Central Kansas (From K.S.B.A. Reports: Colo. Ex. 55, Tr. Vol. XVII, p. 2932, App. "B," p. 9)

	Central Division Totals	Counties Outside of Basin	Wholly or Partly in Basin	In Basin But Not on Ark. River	Counties on Channel of Ark. River
Number of Counties	37	19	18	10	8
Years					
1881	4,096,743	2,029,596	2,067,147	934,938	1,132,209
1885	4,213,876	2,001,520	2,212,356	1,001,632	1,210,724
1888	4,350,209	2,116,195	2,234,014	1,032,979	1,201,035
1890	3,364,542	1,392,527	1,972,015	975,297	996,718
1895	8,687,883	4,219,176	4,468,707	2,065,756	2,402,951
1900	8,322,523	3,958,947	4,363,576	2,069,959	2,293,617
1905	9,212,143	4,364,584	4,847,559	2,346,343	2,501,216
1910	9,719,277	4,572,765	5,146,512	2,543,606	2,602,906
1915	9,389,537	4,553,310	4,836,227	2,453,410	2,382,817
1920	10,652,051	5,004,061	5,647,990	2,802,029	2,845,961
1925	10,228,529	4,524,870	5,703,659	2,808,852	2,894,807
1930	11,000,246	5,160,295	5,839,951	2,885,243	2,954,708

Values of field crops grown in the counties of Central Kansas, shown by years in Colorado Exhibit 66, (Tr. Vol. XVII p. 3980 App. "B." p. 13) are summarized in the following:

TABLE 14

Values of Field Crops in Central Kansas by County Groups

	Counties Outside of Basin	Wholly or Partly in Ark. River	In Basin But Not on Ark. River	Counties on Channel of Ark. River
Number of Counties	19	18	10	8
Years				
1881	$ 18,543,060	$ 24,935,180	$ 10,703,750	$ 14,231,430
1885	17,152,170	18,234,980	8,023,930	10,211,050
1888	19,347,990	19,164,310	8,690,940	10,473,370
1890	12,216,560	17,569,170	8,699,520	8,869,650
81-90*	18,449,700	21,107,400	9,737,200	11,370,200
1895	12,667,290	16,413,460	8,120,039	8,293,421
1900	25,169,420	32,660,430	15,803,630	16,850,680
91-00*	17,842,000	20,676,200	9,904,800	10,771,400
1905	39,745,608	42,135,094	19,566,217	22,568,877
1910	51,129,810	51,394,730	25,931,380	25,463,350
01-10*	40,271,000	45,613,000	22,139,700	23,473,300
1915	66,336,960	60,933,850	31,186,080	29,747,770
1920	129,620,640	118,239,980	55,992,330	62,247,650
11-20*	72,953,000	85,719,000	42,105,000	43,614,000
1925	44,804,530	73,728,480	35,124,580	38,603,900
1930	51,014,760	51,986,270	25,443,380	26,542,890
21-30*	63,743,000	77,639,000	38,506,000	39,133,000

*Values are ten-year averages for decades shown.

Summarized from Colorado Exhibit 68, (Tr. Vol. XVIII, p. 3003; App. "B," p. 15) the per acre values of field crops produced in the counties of Central Kansas by decades, were as follows:

TABLE 15

Summarized

Per Acre Values of Field Crops of Central Kansas

	1881-90	1893-00	1901-10	1911-20	1921-30
State of Kansas 105 Counties	$9.32	$5.08	$8.84	$15.70	$13.26
Eastern Division 37 Counties	9.55	6.05	9.20	17.95	15.35
Central Division 37 County Totals	$9.19	$4.75	$9.25	$15.37	$13.33
19 Outside Counties	8.89	4.59	9.16	14.90	12.83
18 Inside Counties	9.45	4.91	9.34	15.80	13.77
10 Off-Channel	9.27	5.00	9.34	15.60	13.70
8 On River Channel	9.63	4.84	9.34	15.90	13.83

In 1930 there was, in the eight counties in Central Kansas on the Arkansas River, more than 2,900,000 acres of land devoted to the production of field crops (Table 13, p. 94, appendix "(A)"; in the five counties of Western Kansas on the Arkansas River there are approximately 1,200,000 acres producing field crops (Table 16, p. 96, appendix "(A)"; and in addition to the more than 4,100,00 acres of field crops in the Kansas counties crossed by the Arkansas River, there was equal or greater acreage in adjoining counties that, wholly or in part, are located in the basin of the Arkansas River and are drained by its tributaries.

TABLE 16

Acres of Field Crops in Western Kansas
(From K.S.B.A. Reports: Colo. Ex. 57, Tr. Vol. XVII, p. 2943, App. "B," p. 10)

Number of Counties	Western Kansas Totals 31	Counties Outside of Basin 17	Wholly or in Part In Basin 14	in Basin But Not on Channel 9	Counties on Ark. River Channel 5
Years					
1881	154,951	118,706	36,245	32,405	3,840
1885	180,207	131,991	48,216	32,822	15,394
1888	906,293	625,658	280,635	193,420	87,215
1890	716,826	476,401	240,425	150,398	90,027
1895	1,797,118	1,272,282	524,836	335,487	189,349
1900	1,754,797	1,305,698	449,099	290,063	159,036
1905	2,332,076	1,601,237	730,839	456,716	274,123
1910	3,768,027	2,588,281	1,179,746	600,734	579,012
1915	3,652,039	2,539,329	1,112,719	542,547	570,172
1920	4,822,518	3,209,122	1,613,456	815,461	797,995
1927	5,628,260	3,642,228	1,986,032	1,099,984	886,048
1930	7,150,853	4,335,617	2,815,236	1,628,655	1,186,581

In the 5 main-river counties of Western Kansas, wherein the total acreages devoted to field crops in 1905 had attained a total of 274,000 acres, expansion has occurred since 1905 to an extent such that field crop acreages totalled 579,000 acres in 1910; 798,000 acres in 1920; and 1,187,000 acres in 1930.

Values of the field crops grown in Western Kansas and in the county-groups of that division, reported annually by the Kansas Board of Agriculture, and shown in Colorado Exhibit 67, (Tr. Vol. XVIII, p. 2989, App. "B," p. 14), are summarized in the following:

TABLE 17

Values of Field Crops of Western Kansas

Years	17 Counties Outside of Basin	14 Counties Wholly or in Part Inside	9 Counties in Basin Not on Channel	5 Counties on Channel Ark. River
1881	$ 661,155	$ 484,731	$ 440,217	$ 44,514
1885	1,181,037	591,800	386,757	205,043
1888	5,467,330	2,244,780	1,466,600	778,180
1890	2,209,030	2,200,923	1,203,448	997,475
81-90 avg.	2,274,000	1,163,000	735,000	428,000
1895	3,822,672	1,785,394	1,064,818	720,576
1900	5,263,004	2,917,623	1,659,746	1,257,877
91-00 avg.	3,937,600	1,806,900	1,028,000	778,900
1905	14,453,535	5,506,040	3,186,113	2,319,927
1910	17,086,210	10,016,450	4,264,221	5,752,229
01-10 avg.	12,404,900	5,637,500	2,780,600	2,856,900
1915	31,805,450	14,625,635	6,971,434	7,654,201
1920	80,804,820	33,612,830	17,627,000	15,985,830
11-20-avg.	35,021,100	16,498,400	7,535,100	8,963,300
1925	36,149,900	19,058,500	8,720,250	10,338,250
1930	39,517,860	22,096,260	12,046,060	10,050,200
21-30 avg.	38,852,800	24,829,400	12,544,000	12,285,400

Annual values per acre of field crops of Western Kansas, compiled from reports of the Kansas State Board of Agriculture, and shown as decade averages in Colorado Exhibit 68, (Tr. Vol. XVIII, p. 3003, App. "B," p. 15), are summarized in the following:

TABLE 18

Annual Value Per Acre of Field Crops of Western Kansas

	1881-90	1893-00	1901-10	1911-20	1921-30
State of Kansas 105 Counties	$9.32	$5.08	$8.84	$15.70	$13.26
Eastern Division 37 Counties	9.55	6.05	9.20	17.95	15.35
Central Division 37 Counties	9.19	4.75	9.25	15.37	13.33
Western Kansas 31 Counties	7.62	3.26	6.65	13.00	11.10
17 Outside Counties	7.10	3.17	6.66	12.94	10.60
14 Basin Counties	8.89	3.48	6.61	13.10	12.00
9 Off-Channel Counties	8.69	2.99	5.46	11.93	10.80
5 River Counties	9.25	4.48	8.31	14.23	13.50

The relative extent of irrigated and non-irrigated operations in the Arkansas River counties, measured in acres of field crops, may be approximated by comparing the total field crop acreages, including both irrigated and non-irrigated lands, reported by the Kansas State Board of Agriculture, with the irrigated acreages reported by the United States Census Bureau for the same counties, and the same season, as follows:

TABLE 19

Total Field Crop and Irrigated Acreages Counties of Western Kansas on Arkansas River

Season	Total Field Crop Acreages (K.S.B.A.)	Irrigated Acreages (U. S. Census; Table 7) Basin*	5 Counties**
1889	144,216	17,821	17,572
1899	154,810	19,483	18,570
1902	196,375	24,220	.....
1909	534,481	35,357	34,879
1919	781,802	46,539	41,485
1929	1,097,472	68,781	60,897

*Basin areas are exclusive of Cimarron River, but include tributary areas (as Pawnee Creek), and ground water developments (as in Scott County,—i.e., areas in counties other than five river counties.
**Counties are Hamilton, Kearney, Finney, Gray and Ford.

Unit yields are not important when viewed in the light of the agricultural statistics of the United States Census. Referring to the 1930 census it appears (Tr. pp. 3346-3347, Vol. XX) that, in the five Western Kansas counties along the Arkansas River, there were 1,186,581 acres of field crops of which about 62,000, or 5% were irrigated, whereas in the Colorado counties along the stream the total harvested acreage was 510,855 acres, of which 389,435, or 76% were irrigated.

WATER REQUIRED FOR IRRIGATION

As to the Arkansas Valley, Table 8 of Technical Bulletin 36, per Colorado Exhibit 135 (Tr. pp. 1966-1978, Vol. XII, App. "B," p. 27), the recommendations show seasonal net irrigation requirements, as follows: In Division 12, which includes Canon City, Pueblo and the upper Arkansas Valley in that vicinity, 2.1 acre-feet,—compared with about 1.3 acre-feet per Kansas Exhibit 93; Division 13; Arkansas Valley in Colorado down to the Stateline, 2.3 acre-feet,—as compared with values of 1.04 to 1.24 acre-feet, per Kansas Exhibit 93; and Division 14, Southwestern Kansas, 1.75 acre-feet,—as compared with 0.70 to 1.06 acre-feet, per Kansas Exhibit 93. (Tr. p. 1725, Vol. X).

POPULATIONS IN COLORADO AND KANSAS BASINS

The populations of counties along the Arkansas River in Colorado and in Kansas, cited by this court in its opinion and decree of 1907 for the years 1880, 1890 and 1900, are repeated for these years and shown for subsequent census years in the following:

TABLE 20

Populations of Counties Along Arkansas River In Colorado and in Kansas

(As Reported by United States Census Bureau)

	1880*	1890*	1900*	1910	1920	1930	1940
Fremont	4,735	9,156	15,636	18,181	17,883	18,896	19,742
Pueblo	7,617	31,491	34,448	52,223	57,683	66,038	68,870
Otero (1889)	.....	4,192	11,522	20,201	22,623	24,390	23,571
Crowley (1911)	.....	.....	.....	.....	6,383	5,934	5,398
Bent	1,654	1,313	3,049	5,043	9,705	9,134	9,653
Prowers (1889)	.....	1,969	3,766	9,520	13,845	14,762	12,304
Colorado Group	14,006	48,121	68,421	105,168	128,122	139,154	139,538
Hamilton	168	2,027	1,426	3,360	2,586	3,328	2,645
Kearney	159	1,571	1,107	3,206	2,617	3,196	2,525
Finney (1884)	.....	3,350	3,469	6,908	7,674	11,014	10,092
Gray (1887)	.....	2,415	1,264	3,121	4,711	6,211	4,773
Ford	3,122	5,308	5,497	11,393	14,273	20,647	17,254
Western Kansas	3,449	14,671	12,763	27,988	31,861	44,396	37,289
Edwards	2,409	3,600	3,682	7,033	7,057	7,295	6,377
Pawnee	5,396	5,204	5,084	8,859	9,323	10,510	10,300
Barton	10,318	13,172	13,784	17,876	18,422	19,776	25,010
Rice	9,292	14,451	14,745	15,106	14,832	13,800	17,213
Reno	12,826	27,079	29,027	37,853	44,423	47,785	52,165
Sedgwick	18,753	43,626	44,037	73,095	92,234	136,330	143,311
Sumner	20,812	30,271	25,631	30,654	29,213	28,960	26,163
Cowley	21,538	34,478	30,156	31,790	35,155	40,903	38,139
Central Kansas	101,344	171,881	166,146	222,266	250,659	305,359	328,678
Kansas Group	104,793	186,552	178,909	250,254	282,520	349,755	355,967

*Figures for years cited by Court in opinion (*Kansas v. Colorado*—1907).

A second source of information, concerning conditions in the counties of Kansas, appearing in the record as Colorado Exhibits Nos. 43 to 71, (Tr. Vol. XVII and XVIII, pp. 2858 to 3027, App. "B," p. 3-18), are the Biennial Reports officially published by the Kansas State Board of Agriculture.

Of the 105 counties comprising the State of Kansas, 37 are in the Central Division, and 31 are in the Western Division of that state; and of its total area of 82,113 square miles, the Eastern Division involves 27.9 percent, the Central Division 38.6 percent, and the Western Division 33.6 percent thereof. Of the 37 counties in the Central Division, 19 are wholly outside, and 18 are located wholly or in part in the Arkansas River basin; and of these 18 counties, 8 are crossed by the river channel, the names of which appear in the foregoing Table. Of the 31 counties in the Western Division, 17 are outside, and 14 are wholly or in part within the Arkansas River basin; and of these, 5 are crossed by the river channel, the names of which also appear in the foregoing Table.

Arranged in accordance with the three divisions of the state, the populations of Kansas, reported annually by the Kansas State Board of Agriculture as shown in Colorado Exhibit 44, (Tr. Vol. XVII, p. 2858, App. "B," p. 4), are summarized in the following:

TABLE 21

Populations State of Kansas by Divisions

	State Totals	Divisions of Kansas		
		Eastern	Central	Western
Number of Counties	105	37	37(a)	31(b)
Land Areas (Sq. Mi.)	82,113(c)	22,789	31,700	27,634
% of State Area	100	27.8	38.6	33.6
Year				
1881*	925,075	549,705	349,866	25,504
1885	1,268,530	708,861	518,400	41,269
1888**	1,518,552	760,605	621,222	136,725
1890	1,423,485	774,384	548,009	101,092
1895	1,334,734	757,039	501,124	76,571
1900	1,444,708	825,138	539,321	80,249
1905	1,544,968	885,565	565,498	94,085
1910	1,696,361	921,479	639,357	135,525
1915	1,672,545	911,829	635,046	125,670
1920	1,779,936	930,407	698,823	150,706
1925	1,812,986	944,128	705,268	163,590
1930	1,851,024	962,954	720,225	177,845

(a) Includes 8 counties on channel of Arkansas River and 10 other counties wholly or in part in Arkansas River Basin.
(b) Includes 5 counties on channel of Arkansas River and 9 other counties wholly or in part in Arkansas River Basin.
(c) Formerly reported at 82,030 square miles.
*First year of Kansas State Board of Agriculture Reports.
**Approximate peak of land-boom of 1880 decade.

TABLE 22

Populations of Counties of Western Kansas
(From K.S.B.A. Reports: Colo. Ex. 49, Tr. Vol. XVII, p. 2877, App. "B," p. 6)

Number of Counties	Western Kansas Totals	Counties Outside of Basin	Wholly or in Part in Basin	In Basin But Not on Channel	Counties on River Channel
	31	17	14	9	5
Years					
1881	25,504	17,804	7,700	3,932	3,768
1885	41,269	26,040	15,229	7,864	7,365
1888	136,725	84,204	52,521	29,076	23,445
1890	101,092	69,154	31,938	16,498	15,444
1895	76,571	51,908	24,663	12,368	12,295
1900	80,249	55,587	24,662	11,896	12,766
1905	94,085	63,207	30,878	15,514	15,364
1910	135,525	87,664	47,861	19,850	28,011
1915	125,670	79,988	45,682	18,271	27,411
1920	150,706	95,976	54,730	23,016	31,714
1925	163,590	102,760	60,830	26,822	34,008
1930	177,845	105,943	71,902	28,863	43,039

TABLE 23

Populations Central Division State of Kansas
(From K.S.B.A. Reports: Colo. Ex. 46, Tr. Vol. XVII, p. 2867, App. "B," p. 5)

Number of Counties	Central Division Totals	Counties Outside of Basin	Wholly or Partly Inside	In Basin But Not on Ark. River	Counties on Channel of Ark. River
	37	19	18	10	8
Years					
1881	349,866	183,713	166,153	76,579	89,574
1885	518,400	248,264	270,136	120,456	149,670
1888	621,222	283,574	337,648	147,288	190,360
1890	549,009	253,224	294,785	126,106	168,678
1895	501,124	232,720	268,404	115,732	152,672
1900	539,321	250,190	289,131	126,742	162,389
1905	565,498	255,222	310,276	130,481	179,795
1910	639,357	271,783	367,574	144,419	223,155
1915	635,046	272,540	362,506	142,908	219,598
1920	698,823	270,520	428,303	169,130	259,173
1925	705,268	268,719	436,549	159,243	277,306
1930	720,225	262,269	457,956	157,852	300,104

Population of Finney County, Kansas, where the largest irrigated area is situated, as reported annually by the Kansas State Board of Agriculture, and as shown by Colorado Exhibit 52, (Tr. Vol. XVII, p. 2909, App. "B," p. 7) is summarized in the following:

TABLE 24

Population of Finney County, Kansas

Years	Five River Counties	Finney County — County Totals	City of Garden City	Irrigated Townships*	All Other Portions**
1881	3,768	708			
1885	7,365	1,240	378	238	624
1888	23,445	7,386	2,819	927	3,640
1890	15,444	4,064	1,469	878	1,717
1895	12,295	3,529	1,506	950	1,073
1900	12,766	3,214	1,544	801	869
1905	15,364	3,204	1,267	787	1,150
1910	28,011	7,701	3,718	1,937	2,050
1915	27,411	6,016	3,016	1,462	1,638
1920	31,714	7,736	3,887	1,787	2,162
1925	34,008	8,293	4,099	2,091	2,103
1930	43,039	10,974	6,148	2,309	2,517

*Populations of Sherlock and Garden City Townships, in which are located substantially all the irrigated lands of Finney County, but which include, also, some areas of non-irrigated lands. The City of Garden City is surrounded by irrigated lands.

**Populations of all other portions of Finney County are located largely on non-irrigated lands, though minor irrigated areas may be included therein.

WATER RESOURCES IN KANSAS BASIN.

The flow of the Arkansas River from Kansas into Oklahoma (exclusive of the flows of tributaries entering in Oklahoma, including the Cimarron River, and the Verdigris and Neosho-Grand Rivers that together discharge about 4,000,000 acre-feet annually from Kansas into Oklahoma) averaged 1,703,414 acre-feet annually during 1922 to 1931 (Tr. pp. 5759-5780, Vol. XXXII). In this same period the Arkansas at Garden City discharged an average of 191,982 acre-feet per year (Tr. p. 5779, Vol. XXXII), indicating a net gain averaging 1,511,432 acre-feet per year. Rainfall and runoff conditions during the 10-year period were above average. The flow of the Arkansas River, averaging 171,000 acre-feet annually at Garden City, upon arrival at the Kansas-Oklahoma Stateline, has increased to an average of over 1,500,000 acre-feet annually. Since there are uses of the ground waters prior to the discharge of their surplus quantities into the river channel, and since there are conveyance losses between Garden City and the Oklahoma Stateline, due to evapora-

tion and transpiration from the river channel and adjoining bottom lands, the total water resources produced in the basin in Kansas below Garden City are materially greater than in the indicated net river gain averaging about 1,330,000 acre-feet annually.

Bottom lands in all counties of Kansas crossed by the Arkansas River are underlain, at varying but usually shallow depths, with generally abundant supplies of ground waters. In the Central Kansas counties, such bottom lands are not commonly irrigated, whereas in the Western Kansas counties the bottom lands, where soils are suitable for cultivation, are more largely irrigated, either by ditches diverting from the river, or by means of wells and pumps, or both in combination. Such irrigation also extends to and includes some of the uplands (Tr. pp. 5320-5323, vol. XXX).

The combination resource of suitable soils and abundant ground water resources at shallow depths is, as yet, largely undeveloped. Colorado's witness C. L. Patterson testified (Tr. p. 2905, vol. XVII), that irrigation possibilities in Kansas are enormous; that, if developed, Kansas will have a greater irrigated acreage than is possible of attainment in the entire State of Colorado; and, that development of irrigation in Kansas is a matter, in addition to the availability of soil and water resources, that involves balancing the needs for and benefits of irrigation, against the costs of construction and operation of the required facilities. The witness Knapp, as Irrigation Commissioner for Kansas, in his report of 1920-1922 to the Kansas State Board of Agriculture said: (Tr. p. 5412, vol. XXX)

> "The present extent of irrigation in Kansas gives little indication of the irrigation possibilities of the State. The existence of abundant supplies of ground water in many parts of the State, together with the uniformly beneficial results obtained where irrigation is now practiced, indicates that as population increases, as land values become higher, and as the value of ir-

rigation becomes more generally appreciated, the acreage will be greatly increased."

Among other of the state's promotional activities, were the installation and operation of demonstration pumping plants. At times, practically the entire time of his department has been spent on such work (Report of 1924-1926; Tr. p. 5415, vol. XXX). Stating that the biennium 1924 to 1926 had been outstanding in the development of pump irrigation, and that the work had brought out a number of interesting things, Mr. Knapp said:

> "As a means of providing a water supply to insure crops against the injurious effects of irregularly occurring drouths in a region such as this (The State of Kansas), pump irrigation is better adapted to the situation than other methods, in that it is cheaper, and comes nearer meeting the requirements of an irrigation enterprise in the semi-humid belt than would great ditch systems such as those in the West."

Among other advantages of pump irrigation, cited by the witness Knapp, are the following: pumped water costs but little, if any, more than maintenance and operating charges under a river ditch furnishing its water users a dependable supply of water (Tr. p. 5418, vol. XXX); the pumping plant provides an adequate water supply which can be made available on short notice, whereas the long canal functions best under continuous use, but conditions in the Great Plains region are such that continuous operation is not required nor even desirable, for during a considerable portion of the crop growing season natural precipitation is sufficient for the needs of crops (Tr. p. 5419, vol. XXX); the pumping plant can set unused for long periods of time, and when idle requires little or no maintenance, whereas an irrigation canal requires constant maintenance, — an item of expense which must be met whether the canal is in use or not, and a charge to be figured on during a wet year as well as a dry year, because the problem of keeping a canal free from weeds and ready to operate is a bigger one in a wet season when that

canal is not carrying water than when it is (Tr. p. 5420, vol. XXX); and by the use of a pumping plant the farmer enjoys complete independence in the use of water, while under a ditch each man must take his water when his turn comes, in many instances when he is not ready for it. (Tr. Vol. XXX. p. 5421)

Underground water resources of and along the Arkansas River in Kansas are extensive. Such resources along the river section between the Colorado Stateline and Garden City first began to be developed, in a major way, during the period of the original *Kansas v. Colorado* case. The federal government aided in the development, among other ways, through the Slichter investigations (Tr. p. 3520, Vol. XXI) and report on ground water resources; and through the construction by the United States Reclamation Bureau of the Deerfield pumping project for and in behalf of the Kansas Farmers ditch of the Finney County Water Users' Association. This project, though rejected by its beneficiaries after about two years of operation in the seasons of 1909 and 1910 (Tr. pp. 3520-3530, Vol. XXI), has recently been revived and again placed in operation. (Tr. p. 7055, Vol. XXXIX). In the meantime numerous farmers have installed individual pumping plants, which furnish irrigation supplies when and as needed at costs similar to those encountered under gravity ditches, and commonly less than are involved under ditch irrigation where reservoir costs are a part of the total.

Out of a total in the entire State of Kansas of 99,980 acres irrigated in 1939, counties in the Arkansas River basin, including Scott County, but exclusive of areas in the Cimarron, Smoky Hill, Republican and other stream basins in Kansas, embraced 94,064 acres or 94 percent of said total (Census Bureau Report).

Among the recent developments is the one in Scott County, where ground waters are found at depths of 40 to 60 feet or more, previously thought to be beyond the limits of successful pumping for general agricultural purposes. U. S. Census data shows 150 acres irrigated in 1909;

3,047 acres in 1919; 3,432 acres in 1929; and 13,389 acres in 1939 (Colorado Exhibit 196, Tr. vol. XXXVII, p. 6551; App. "B," p. 47-51).

South of the Arkansas Valley in Western Kansas is another disappearing stream, namely, Bear Creek (Colorado Exhibit 205, Tr. vol. XXXVII, p. 6607; App. "B," p. 59), draining an area of 1,580 square-miles, of which 950 thereof are in Colorado. At times of intense rains over its catchment area, floods occur in Bear Creek which, upon arrival at the sand-hills, disappear at a point south of Lakin, Kansas. Disappearance is due in part to evaporation and in part to absorption and percolation into the sands. These percolating waters, like the rainfall on the sand-hills, contribute to the ground water resources of the Arkansas River Valley.

The relations between rainfall and ground water levels are described by Kansas Irrigation Commissioner Knapp, at page 31 of his 1920-1922 Report to the Kansas State Board of Agriculture, who testified therefrom (at Tr. pp. 5320-5323, vol. XXX) as follows:

> "The water supply of the lower Arkansas valley presages a much greater irrigation development than is evidenced by the present irrigated acreage. That broad valley, widening as it does to almost a level plain, which includes the Rattlesnake and Ninnescah, small tributaries of the Arkansas River, is, for the most part, underlaid with an abundant supply of water. In many respects it is one of the best-watered valleys in the state. The depth to water is not great, varying from ten to twenty feet below the surface. Under these conditions, pumping plants are comparatively inexpensive. Distance to market here is short. The seasons are long, and a great variety of crops can be grown."
>
> . . . . . .
>
> "Whenever ground water is used for irrigation the question of the adequacy of the supply invariably

rises. A study of the water supply of this valley leaves little room for apprehension. The water-bearing stratum, composed of sand and gravel, is in effect a large storage reservoir. Considering the fact that the river, which naturally flows in the lowest part of the valley, acts as a drain to carry off surplus ground water, it is evident that this reservoir must be full to overflowing whenever there is running water in the river. No one would expect to use water from an ordinary storage reservoir without lowering the water surface, and the mere fact that the ground-water elevation drops during the irrigation season is no cause for alarm. The real test is whether or not the water supply of the valley is sufficient to fill the subterranean reservoir each year during the non-irrigating season. It not only does this, but each year more than a million acre feet of water flows out of this valley on its way to the ocean."

During the 1890 decade the ditches of Western Kansas were largely useless and of little value. Early in 1890 the Garden City ditch and the Kansas Farmers ditch were sold to a company known as the Garden City Irrigation Company, the owners of which also acquired the Southwestern Irrigation Company and its ditch now known as the Great Eastern. All three ditches were thereafter operated by Superintendent F. W. Denny (Tr. p. 3462, vol. XX) during the seasons of 1890 to 1894. Irrigated acreages which had expanded during the years of the 1880 decade began to decline in 1889. For example: Under the Kansas Farmers ditch 150 acres were irrigated in 1882; from 2,000 to 3,000 acres in 1883; from 3,000 to 4,000 acres in 1884; between 4,000 and 5,000 acres in 1885; 5,000 acres from 1886 to 1888; and 4,000 acres in 1889 (Tr. p. 3467, vol. XX). After several years of Denny management the said irrigation companies became bankrupt and went into receivership. Similiar plans prevailed at the time under other ditches including those now known as the South Side and Amazon (Tr. p. 3496, vol. XXI), located upstream in Kearney County. In 1894 Mr. Thos. E. Dewey was appointed

receiver, taking charge on June 1, 1894, though his official appointment as receiver of the Southwestern Irrigation Company was dated September 29, 1894 and of the Garden City Irrigation Company was dated July 10, 1894. Mr. John E. Edwards was made superintendent of all three ditches (Garden City, Farmers and Great Eastern), and acted in that capacity during the seasons of 1894 and 1895 (Tr. p. 3502, vol. XXI). In 1895 all three ditches were cleaned out, and their dams and headgates were reconstructed. Little, if any, irrigation was then being accomplished. Farmers were refusing to buy water, some were plowing up their irrigation laterals, while others instituted suits against the companies. (Tr. p. 3503, vol. XXI). The receiver reported that in 1896 but one flood came down the river, that no attempt was being made by him to operate the ditches, that the services of superintendent Edwards had been dispensed with, and that his efforts as receiver were being directed solely to the sale of the ditches (Tr. p. 3504, vol. XXI). During the three years 1897, 1898 and 1899, receiver Dewey attempted to lease each of the ditches to some one farmer thereunder, holding the one farmer responsible for the collection of payments from his neighbor water users. No one leased the Great Eastern ditch. Mr. C. E. Sexton leased the Kansas Farmers ditch for $2,000 per season, but made only one payment in the three years. In 1899 the total acreage irrigated under the Kansas Farmers ditch was 1,000 acres (Tr. p. 3505, vol. XXI). During 1900 and 1901 receiver Dewey made no effort to operate any of the ditches either directly or by lease, and stated that if any operation was carried on it was done by some individual farmer or group of farmers without his knowledge. From the physical standpoint the several ditches of Western Kansas as of the year 1900 were in fact largely useless (Tr. p. 3505, vol. XXI). Little value was assigned to the water rights and the irrigation facilities at the time. The 12th U. S. Census Report, for the year 1900, contains the following (Tr. p. 3506, 3507, vol. XXI):

"The history of irrigation in Kansas has been marked by a number of disastrous failures, most of them resulting from a lack of knowledge of the climatic oscillations in the sub-humid regions and from a fever of speculations in western mortgages. During a cycle of wet years agriculture was extended far into the plains region. The movement westward was greatly facilitated by companies which were formed to place loans and to take mortgages on real estate, the funds being obtained from the east. As long as the rainfall continued abundant, the profits of these loan agencies were great, and the competition became so keen that ordinary prudence was thrown aside. When a series of dry years came and crops failed season after season, the land owners abandoned their farms, leaving whole counties practically deserted. The loan companies foreclosed their mortgages and became possessors of large tracts of land, which were comparatively valueless. In order to make their property marketable, the corporations organized new companies, sold stock, and in the southwest part of the state (referring to the State of Kansas) constructed some of the largest irrigation canals in the United States. These ditches and canals have never given adequate returns upon the large investments, owing to the fact that no study had been made of the volume of water in the streams, or of any of the important conditions relating to the diversion of water from them."

"The water supply for most of these ditches was to have been taken from the Arkansas River, but it proved wholly inadequate for that purpose, and hundreds of miles of ditches had to be abandoned. The principal irrigated areas are along this river, where conditions are somewhat similar to those along the Platte River in Nebraska. Its broad, shallow channel is dry for a considerable part of the year; water, however, is seeping beneath the surface of the valley lands, as well as under the stream bed. The ditches operated at the present time can receive water only

at times of flood, and are utilized largely in the cultivation of forage crops."

When about 1890 the irrigation ditches then constructed in Western Kansas were confronted with problems and difficulties arising from an absence of surface flows in the Arkansas River, they requested assistance from the federal government in connection with the development of underground supplies. After the plan then proposed, of building so-called underflow ditches, had failed, the United States Geological Survey, beginning in 1900, undertook an investigation of ground water resources, under the direction of Charles S. Slichter. Results of the investigations were published in 1906 in Water Supply and Irrigation Paper No. 153, entitled: "The Underflow of the Arkansas Valley in Western Kansas" (Tr. p. 3521, vol. XXI). Shortly thereafter the United States Reclamation Bureau constructed a power project and pumping plant on the river near Deerfield, under an agreement with the Finney County Farmers Irrigation Association, then owner of the Kansas Farmers Ditch, to serve the 10,677 acres of irrigable land thereunder. Construction was completed during 1906 and 1907 and the project began delivering water April 1, 1908 from batteries of wells surrounding ten pumping units. Difficulties were encountered, due to the necessity of cleaning the wells of sand. In 1908 the pumped waters were used to irrigate 4,885 acres. On November 30, 1908, a public notice was issued, showing that construction costs, originally estimated at $35.00 per acre, would actually amount to $37.50 per acre of irrigable land in the project. Operation for the 1909 season commenced April 5th. By the end of June, 75 certificates had been issued providing water rights for 6,976 acres of land. The 7,555 acre-feet of water pumped in 1909 was used on 6,545 acres of land. Operation of the project during 1908 and 1909 demonstrated that, with all the difficulties, results were fairly successful though costs were necessarily high.

"This circumstance, and the fact that rainfall is usually sufficient to secure the maturing of crops has apparently lessened the desires of the land owners for an irrigating system; and the payments of the reclamation charges, as they became due, have not been made."

"Inasmuch as the public notices that have been issued provide that no water shall be furnished in any irrigation season until the operation and maintenance charges of the previous season have been paid, the plant has been closed down and put in charge of a caretaker. Future operations will depend on the action of the settlers." (Tr. p. 3524, vol. XXI).

This Reclamation Bureau irrigation project, abandoned in 1910 by the settlers under the Kansas Farmers Ditch, by reason of their unwillingness to repay construction charges of $37.50 per acre, as opposed to original estimates of $35.00 per acre, and to pay annual maintenance and operation charges that ran about $1.00 per acre higher than original estimates (Tr. p. 3525, vol. XXI), has recently been rehabilitated and is now in operation by local interests, apparently without reimbursement to the federal treasury. The original difficulties due to sand accumulating in wells, under this and other privately constructed projects, were later overcome by improvements in well construction. And the mistake of concentrating too many wells in one restricted area, could at any time have been corrected.

During the same period of 1906 to 1910 many individuals were installing wells and pumping plants, and the United States Sugar and Land Company began sinking wells in the river valley and on the uplands in the general vicinity of the Reclamation project at Deerfield. These separated and individual types of groundwater development appear to have functioned with somewhat better efficiency and satisfaction. In the shallow-lift areas of the Garden City and similar districts they have been highly successful (Tr. p. 3527, vol. XXI). In addition to the con-

tinuous flow through the underflow conduit, the sands and gravels therein constitute a natural underground reservoir which is supplied both by rains upon the valley lands and the adjoining sand hills, and by surface flows in the river channel (Tr. pp. 3528-3530, vol. XXI).

At the present time the irrigated acreage in Hamilton, Kearney and Finney counties (Kansas), approximates 60,000 acres (Tr. pp. 6553-6562, Vol. XXXVII, pp. 6837-6839, vol. XXXVIII). Of the total area being irrigated, 3,156 acres thereof are located outside of and away from constructed ditches that divert from the Arkansas River, and 56,476 acres are located under and are irrigable from the constructed river ditches. Of these irrigable lands under ditch, 3,179 acres are supplied exclusively with ground waters by means of wells and pumps. Hence, 53,277 acres are dependent, wholly or in part, upon river water. Of this total, 24,038 acres thereof are equipped with individual pumping plants, and hence, may be irrigated with river water or well water or both. This leaves 29,239 acres without individual pumping plants. However, 6,811 acres thereof, largely under the Kansas Farmers Ditch, are located under and may obtain water from the battery of wells and pumps installed during 1906-1907 and operated during 1908-1909 by the U. S. Reclamation Bureau and thereafter abandoned until recently rehabilitated and placed in operation by local interests. Thus the total acreage dependent solely on stream flows in the Arkansas River in Hamilton, Kearney, and Finney counties aggregates 22,425 acres; and the acreage served wholly or in part with ground waters by means of wells and pumps total 37,387 acres.

There are available conservation and storage possibilities in the Arkansas basin in Western Kansas. These are described in detail in Colorado Exhibits 136-144 (App. "B," p. 28) and in testimony (Tr. pp. 3310-3325, Vol. XX).

Lake McKinnie reservoir was constructed in Kearney County, Kansas, about 1908 to a capacity of about 25,000 acre-feet, and has since operated continuously and ef-

fectively. Through capturing portions of the non-seasonal or winter stream flows and of the summer floods, which previously were unusable, wasted and without benefit, Lake McKinnie reservoir has increased the total diversions made by ditches in Kansas, has increased the acreages irrigated, and has increased the benefits to Kansas arising from the interstate stream. Other similar reservoir sites are located in Kansas, but as yet have not been developed. Among these are Bear Valley Reservoir site (Colorado Exhibits 136-138, Tr. Vol. XX, p. 3310), and others, including sites designated Kendall, West Kansas, Syracuse, Kansas-Colorado and Lake McKinnie enlargement (Colorado Exhibit 139, Tr. Vol. XX, p. 3320; App. "B," p. 28). Undiverted and unused stream flows have been and are available for capture and storage in such reservoirs, if and when constructed (Colorado Exhibit 140-144, Tr. Vol. XX, pp. 3320, 3323). During the period 1908 to 1938, the constructed ditches in Kansas diverted from the Arkansas River an average of 89,000 acre-feet annually, for direct application and storage (Colorado Exhibit 211-215, Tr. Vol. XXXVII, pp. 6646-6673; App. "B," p. 63-67). There remained an average of 171,000 acre-feet annually to flow by the Garden City station and beyond the last of the ditches in Kansas (Colorado Exhibits No. 140, Tr. Vol. XX, p. 3320, No. 193, Tr. Vol. XXXVII, p. 6509, No. 204, Tr. Vol. XXXVII, p. 6605; App. "B," pp. 54-58).

VARIABILITY OF RIVER FLOW.

Variable amounts of the stateline flows are an inherent characteristic of the situation. There is no evidence to show that the stateline flow is any more spasmodic now than under conditions prior to irrigation, or that the conditions are now different than they were when the former case was before the Court.

The amended complaint of Kansas in that case, as summarized by the Court (206 U. S. 52), contained this allegation:

"* * * by the year 1891 all the natural and normal waters and a large portion of the flood waters of the Arkansas River were so appropriated and diverted and actually applied to these dry, barren, arid, non-riparian, and non-saturated lands in the State of Colorado, said diversions increasing from year to year, as their means of diversion became more complete and perfect so the average flow of the river was greatly and permanently diminished and the normal flow of the river, exclusive of floods, was wholly and permanently destroyed, * * * and the water for the irrigation ditches in the western part of Kansas has been entirely cut off."

The Court deemed as proved:

"That there is a great variance in the amount of water flowing down the channel at different seasons of the year and in different years is undoubted; that at times the entire bed of the channel has been in places dry is evident from the testimony".

Kansas v. Colorado, 206 U. S. 46, 115.

The Master in his report here also finds:

"The character of the flow of the river in Colorado is variable from year to year and season to season and day to day, and the main river at any one point may be almost without water one day and have a flood in it the next day and the following day have practically its original condition."

(Master's Findings Fact "Second"—Report p. 5.)

The state line flow is portrayed for each day of the 31 years from 1908 to 1938, by Colorado Exhibit 208 (Tr. p. 6639, Vol. XXXVII; App. "B," p. 60), values being in cubic feet per second. Monthly and annual values in acre-feet are tabulated in Colorado Exhibit No. 204 (Tr. p. 6605, vol. XXXVII; App. "B," p. 54-58), and No. 209 (Tr.

p. 6640, vol. XXXVII; App. "B," p. 61). Stateline flows, by years, ranged from minimum values of 54,000 to 59,000 acre-feet in years such as 1917, 1918, 1932 and 1934, to maximum values approximating 800,000 acre-feet, as in 1923, and to 960,000 acre-feet, as in 1921. During the 31-year period the Stateline flow averaged 260,700 acre-feet per year.

The 260,700 acre-feet of water flowing from Colorado into Kansas, in the average year of the 1908 to 1938 period, was partially used and partially unused in Kansas. An average of 89,700 acre-feet thereof, or about one-third of the total, was consumptively used, and an average of 171,000 acre-feet, or about two-thirds thereof, was unused and flowed by Garden City and out of the irrigated region unconsumed (Colorado Exhibit 212, Tr. vol. XXXVII, p. 6651; App. "B," p. 64).

The 89,700 acre-feet of water annually used in Kansas between the Stateline and Garden City was consumed by its diversion and use incident to irrigation and storage, and by natural losses in its conveyance through the river section. Diversions for irrigation and storage averaged 84,900 acre-feet annually (Colorado Exhibit 213, Tr. Vol. XXXVII, p. 6653; App. "B," p. 65). The remaining 4,800 acre-feet of water used in Kansas represents the amount by which natural channel losses exceed tributary contributions and return flows to the river section. Natural channel losses include the consumption of water by evaporation and transpiration, as well as percolation losses incident to recharging the underground reservoir to replace waters consumed through their utilization by means of wells and pumps. Tributary inflows include both surface runoff, as from the several unnamed tributaries entering from the north side, and underground contributions, as from the sand-hill areas south of the river channel in Kansas.

The 171,000 acre-feet of unconsumed outflows passing Garden City in the average year consisted of stream flows in winter months, averaging 54,100 acre-feet per winter season; and of stream flows in summer months, averaging 116,900 acre-feet per season.

Total Stateline flows each year of the 1908 to 1938 period and segregations thereof with respect to divertibility, as compiled from Colorado Exhibits No. 209 (Tr. p. 6640, vol. XXXVII; App. "B," p. 61) and No. 211 (Tr. p. 6646, vol. XXXVII; App. "B," p. 63), are shown in the following:

TABLE 25

Flow of Arkansas River Across the Stateline From Colorado into Kansas—Period 1908-1938 (Annual Values in Acre-Feet)

Year	Totals (Colo. Ex. 209)	UNDIVERTIBLE* (Colo. Ex. 211)	DIVERTIBLE (Colo. Ex. 211)
1908	560,800	406,100	154,700
09	251,400	47,500	204,000
1910	119,400	12,000	107,400
11	107,200	5,200	102,000
12	222,700	38,300	184,400
13	115,300	10,300	105,000
14	576,500	260,600	315,900
1915	495,700	150,500	345,200
16	144,300	24,800	119,500
17	59,400	0	59,400
18	58,900	0	58,900
19	225,900	18,500	207,400
1920	199,200	8,400	190,800
21	961,400	582,500	368,900
22	93,700	0	93,700
23	800,800	298,700	502,100
24	292,600	0	292,600
1925	254,000	71,000	183,000
26	102,900	0	102,800
27	452,900	242,900	209,900
28	264,200	67,600	196,600
29	250,800	75,300	175,500
1930	205,500	12,300	193,200
31	107,200	0	107,200
32	58,500	0	58,300
33	173,000	25,800	147,200
34	54,100	3,800	50,300
1935	193,200	47,000	146,200
36	345,000	174,900	170,100
37	132,300	41,700	90,600
38	204,500	33,300	171,200
AVGE.	260,700	86,100	174,700

*Quantities in flows at rates in excess of 2,000 c.f.s.

Further segregations of the divertible Stateline flows, shown as annual values in the foregoing, as between summer seasons (Apr. to Sept.) and winter months (Oct. to Mar.), are shown in the following:

TABLE 26

Divertible Stateline Flows—Period 1908 to 1938

(Values in Acre-Feet)

(Colo. Ex. 211; Tr., p. 6646, Vol. XXXVII; App. "B," p. 63)

Year	Annual	Winter	Summer
1908	154,700	109,800	44,900
09	204,000	62,100	141,900
1910	107,400	41,900	65,500
11	102,000	59,400	42,600
12	184,400	88,700	95,700
13	105,000	82,100	22,900
14	315,900	48,700	267,200
1915	345,200	66,000	279,200
16	119,500	74,400	45,100
17	59,400	40,400	19,000
18	58,900	32,600	26,300
19	207,400	76,400	131,000
1920	190,800	81,100	109,700
21	368,900	60,400	308,500
22	93,700	57,600	36,100
23	502,100	188,000	314,100
24	292,600	189,100	103,500
1925	183,000	63,500	119,500
26	102,800	48,000	54,800
27	209,900	49,700	160,200
28	196,600	62,700	133,900
29	175,500	91,000	84,500
1930	193,200	126,200	67,000
31	107,200	69,300	37,900
32	58,300	28,200	30,100
33	147,200	26,300	120,900
34	50,300	21,200	29,100
1935	146,200	17,700	128,500
36	170,100	32,000	138,100
37	90,600	23,400	67,200
38	171,200	29,900	141,300
AVGE.	174,700	66,100	108,600

The flow of the Arkansas River across the Stateline from Colorado into Kansas consists of waters originating largely below La Junta, i.e., of floods originating in plains drainage areas tributary to the main river below La Junta, and of return flows from ditches and lands along the stretch of river between La Junta and the Stateline. Little of the stream flows above La Junta reach the Stateline, though at times, as in 1921, floods originate in foothills and plains areas above La Junta that create stream flows at rates in excess of diversion capacities of ditches above La Junta, both from melting snows in mountainous headwaters and from rains on foothills and plains drainage areas, are diverted for irrigation and storage purposes by ditches with points of diversion above La Junta.

All the stream flows passing La Junta, except the crest flows of occasional major upstream floods, are diverted and used for direct application by ditches in Colorado downstream from La Junta. Considered as averages for the period 1908 to 1938, the total flow of the Arkansas River at La Junta, including flood volumes, averaged 189,200 acre-feet annually (Colorado Exhibits No. 204 (Tr. vol. XXXVII, p. 6605; App. "B," p. 54-58), and No. 207 (Tr. vol. XXXVII, p. 6633), and diversions by ditches in Colorado below La Junta averaged 192,700 acre-feet annually (Colorado Exhibits No. 207, (Tr. vol. XXXVII, p. 6633) No. 210 (Tr. vol. XXXVII, p. 6644; App. "B," p. 62). The Stateline flow averaging 260,700 acre-feet annually (Colorado Exhibit 209, Tr. vol. XXXVII, p. 6640; App. "B," p. 61) was caused by or resulted from accretions between La Junta and the Stateline.

Return flows arriving at the Stateline originate along the Arkansas River below La Junta. Return flows reaching the river upstream from La Junta are diverted by ditches along that stretch of river. Return flows below La Junta come from the irrigated lands along the river between La Junta and the Stateline, and from waters diverted by ditches along that river section, together with diversions

made by the Ft. Lyon system at points above La Junta for the irrigation of lands below. Ditches in Colorado have rediverted and reused the increased amounts of return flows. Ditches in Kansas have benefitted from the increased return flows in Colorado, and specifically from those portions thereof which, being unconsumed in Colorado, have reached the Stateline and have entered Kansas and the ditches of that state (Tr. pp. 6643-45, vol. XXXVII). These increased return flows at the Stateline have, in fact, created a water supply usable and used by ditches in Kansas, that previously was non-existent, and its points of origin downstream in Colorado precludes its further re-diversion or depletion in that state.

Flood flows crossing the Stateline from Colorado into Kansas originate largely from the 11,604 square miles of drainage area tributary to the river section below La Junta (Colorado Exhibit 205, Tr. Vol. XXXVII, p. 6607; App. "B," p. 59). The principal tributary of the Arkansas River, namely, the Purgatoire River, enters this river section. No reservoirs have been constructed on its channel, and practically the only use of its waters for storage purposes is by means of a feeder ditch near Trinidad leading to the reservoir of the Model Project, constructed about 1908. Similar feeder ditches as Horse Creek and Adobe Creek, constructed prior to 1910, intercept portions of the flood waters from headwater areas of those tributaries, which waters, being conserved in Horse Creek and Adobe Creek reservoirs and applied to lands under the Ft. Lyon system, contribute to the return flows from that enterprise, and hence, in part, to the unconsumed return flows at the Stateline. Other tributary channels entering the river in Colorado below La Junta include Gageby, Rule, Caddoa, Mud, Limestone, Big Sandy, Buffalo, Wild Horse, Cheyenne, Two Buttes, Granada, Wolf, Clay, Willow, and dozens of other miscellaneous creeks or channels. On none of the tributaries have channel reservoirs been constructed, with two exceptions, namely, Two Buttes Reservoir controls the runoff from headwater areas

of Two Buttes Creek; and Muddy Creek Reservoir controls the runoff from headwater areas of Muddy Creek, a tributary of Rule Creek. The Muddy Creek Reservoir is substantially abandoned. Otherwise the floods from the entire tributary area below La Junta are uncontrolled and reach the main river today in the same manner and to the same extent as occurred under pre-irrigation conditions.

Considering the flows of the Arkansas River as recorded at Canon City gaging station (without adjustments for by-passed and imported quantities), the minimum, average, and maximum rates, in cubic-foot-per-second units, each year of the period 1908-1938, are shown in the following:

TABLE 27

Range in Daily Flows of Arkansas River at Canon City, Colo.

Daily Record 1908-1930 from Kans. Ex. 13; Tr. Vol. IX, p. 1434, 1931-1938; From Colo. Ex. 192, Tr. Vol. XXXVII, p. 6499—Period 1908-1938

Cubic Feet Per Second

	Min.	Avge.	Max.
1908	148	472	1,904
09	236	912	4,328
1910	210	688	3,340
11	242	884	3,490
12	300	857	4,000
13	335	593	2,060
14	330	913	4,800
1915	315	679	2,980
16	354	866	3,050
17	300	852	4,760
18	120	814	4,950
19	340	805	3,030
1920	195	869	3,930
21	210	916	4,980
22	269	710	2,940
23	242	901	3,130
24	235	837	5,260
1925	157	506	1,780
26	233	688	3,520
27	232	761	3,380
28	242	707	3,930
29	265	808	2,800
1930	266	637	2,470
31	144	374	1,390
32	167	629	3,040
33	136	539	3,110
34	151	340	1,460
1935	90	649	4,260
36	177	815	2,780
37	198	529	2,420
38	220	741	3,510
AVGE.	228	719	3,315

The least flow ever recorded in any one day was 90 cubic feet per second. Minimum flows each year ranged from 90 to 354 and average 228 cubic feet per second. Average flows at the Canon City station ranged from 340 cubic feet per second in the year of least discharge, to 916 cubic feet per second in the year of greatest total flow, and, in the average year of the period, averaged 719 cubic feet per second. Maximum stream flows at Canon City, at the crest of the snow-melt or June-rise period, ranged from 1,390 to 5,260 and average 3,315 cubic feet per second.

The monthly distribution of the flow of the Arkansas River at Canon City, average, minimum, and maximum, expressed in cubic feet per second, are shown in the following:

TABLE 28

Average Discharge of Arkansas River at Canon City
By Months: Period 1908-1938
From Acre Foot values in Colo. Ex. 204,
Tr. Vol. XXXVII, p. 6605, App. "B," p. 54-58.

(Values in Cubic Feet per Second)

Months	Avge.	Min.	Max.
January	336	247	467
February	329	230	468
March	333	178	553
April	401	155	854
May	1050	340	1932
June	2197	576	3384
July	1446	305	2508
August	882	262	1523
September	495	189	1366
October	421	184	1196
November	376	204	621
December	359	249	497
Annual	719	340	916
Summer (a)	1080	448	1432
Winter	357	232	521

(a) Months April to September inclusive.

In winter months the Canon City flows range from 232 to 521 cubic feet per second, averaging 357; and in summer months, April to September, inclusive, including the June rise, they range from 448 cubic feet per second under minimum conditions, to 1,432 cubic feet per second under the most favorable water supply conditions, and in usual seasons the average is 1,080 cubic feet per second. In the summer season from April first to September thirtieth, inclusive, a period of 193 days, the flow of the Arkansas River at the Canon City gaging station during the average season of 1908-1938, as counted from the daily record thereof (Kansas Exhibit 13 for 1908-1930, Tr. vol. IX, p. 1439; Colorado Exhibit 192, Tr. vol. XXXVII, p. 6439, for 1931-1938), exceeded given rates for the number of days, as follows:

TABLE 29

Rates (C.F.S.)	No. of Days
200	178
300	161
500	126
700	102
1,000	76
1,500	46
2,000	27
2,500	15
3,000	6

Observed and measured ranges in volume are probably greater than prevailed under virgin or natural conditions, prior to the earliest permanent settlements and the first diversions and uses of the waters of the river, which date from 1859, following the discovery of gold in Colorado in the summer of 1858. Inherent features attending the establishment of civilizations included the deforestation that accompanied mining operations and grazing by livestock interests. Together these affect the character, if not to some extent the amount, of the stream flows, by hastening the speed of runoff, thus increasing the inten-

sities of floods. By reducing the periods of absorption by soils, the contributions of precipitation to the ground waters were decreased, and thus diminished the low or base flows of the streams (Tr. p. 3376, vol. XX).

Diversions from surface flows in the Arkansas River, for purposes of irrigating lands in Hamilton, Kearney and Finney counties are now and during recent years have been greater than the diversions made during and prior to the original interstate litigation. As previously mentioned, Lake McKinnie reservoir was constructed in Kearney County and came into operation just about the time or shortly after the decree therein was entered in 1907. Diversions for storage purposes in Lake McKinnie have since been made each year from winter stream flows and summer floods to an extent, averaging about 25,000 acre-feet annually, such as to provide for releases from storage averaging about 18,000 acre-feet per irrigation season. During the period since the original interstate litigation, and since Lake McKinnie reservoir came into operation, the diversions from surface flows in the Arkansas River of all ditches in Hamilton, Kearney and Finney counties in Kansas, though varying from year to year in accordance with fluctuations in natural precipitation and runoff, have gradually increased in amount. Annual and summer (April to September) diversions in acre-feet, by years, and by six-year averages, for the period 1908 to 1938, compiled from Colorado Exhibit 213, (Tr. p. 6653, vol. XXXVII; App. "B," p. 65), are shown in the following:

TABLE 30

Diversions from Arkansas River by Ditches In Hamilton, Kearney and Finney Counties, Kansas

(Values in Acre-Feet; From Colo. Ex. 213, App. "B," p. 65)

Year	Annual	Six Year Averages	Summer Apr.-Sept.	Six Year Averages
1908	45,000		30,000	
09	93,000		80,000	
1910	57,000		45,000	
11	56,000		40,000	
12	75,000		65,000	
13	29,000	59,200	20,000	46,700
14	96,000	67,700	85,000	55,800
1915	105,000	69,700	90,000	57,500
16	82,200	73,900	41,400	56,900
17	54,300	73,600	17,100	53,100
18	69,300	72,600	26,900	46,700
19	99,000	84,300	58,500	53,200
1920	111,700	86,900	73,700	51,300
21	71,000	81,200	41,600	43,200
22	56,400	77,000	35,200	42,200
1923	116,600	87,300	93,200	54,800
16-Yr. Avge.	76,000		52,700	
1924	55,700	85,100	46,500	58,100
1925	117,500	88,200	65,000	59,200
26	78,700	82,600	47,300	54,800
27	127,800	92,100	89,400	62,800
28	85,500	97,000	40,500	63,600
29	123,400	98,100	62,000	58,400
1930	116,600	108,200	60,200	60,700
31	61,900	99,000	28,500	54,600
32	54,200	94,900	33,700	52,400
33	110,600	92,000	84,200	51,500
34	46,800	85,600	23,400	48,700
1935	102,100	82,000	85,200	52,500
36	120,200	82,600	84,000	56,500
37	69,900	84,000	55,600	61,000
1938	145,200	99,100	122,700	75,800
15-Yr. Avge.	94,400		61,800	
31-Yr. Avge.	84,900		57,100	

EFFECT OF MASTER'S RECOMMENDED DECREE.

The Master's report proposes that Colorado be obligated to deliver at the State line, for the benefit of Kansas, the quantities of water therein specified (pp. 11, 12, 15, 16, 20—Master's Report).

Under such a plan, Colorado would be required to stand, out of its share of the total supply, all the natural losses of water incident to its conveyance from the various points of origin to the Stateline, and thus to overcome a burden which nature imposed on the river and on Kansas, (Tr. pp. 3361-65, Vol. XX).

Being downstream, Kansas will in any event and inevitably receive all the so-called non-dependable stream flows —i. e., the runoff of abnormally wet years. Since total original production in Colorado including both so-called dependable and non-dependable runoff, is found by the Master as 1,240,000 acre-feet, and since the so-called dependable production is estimated by him at 1,110,000 acre-feet, the non-dependable portion, amounting to 140,000 or 190,000 acre-feet will also flow down into Kansas, in addition to the 185,000 acre-feet of dependable supply specified.

It is not certain that the said increased stream flow and water supply would be utilized in Kansas, or that the required works and facilities, to serve the claimed acres of land in Kansas (Tr. p. 1736, Vol. X), would be designed and constructed.

The Master's report proposed allocation to Colorado of 925,000 acre-feet of the so-called "average annual dependable water supply of the Arkansas River and of the stream flow of the river and its tributaries" (Master's Report, pp. 10, 12, 14, 16, 19), necessarily means that the diversions of ditches in Colorado from the Arkansas River, heretofore averaging about 1,000,000 acre-feet annually, be restricted to 925,000 acre-feet per year. By reason of reduced diversions, the return flows will necessarily decline.

The Arkansas River, in its natural condition, was a very intermittent river and frequently disappearing stream.

The character of the flow of the river in Colorado is variable from year to year and season to season and day to day and the main river at any one point may be almost without water one day and have a flood in it the next day and the following day have practically its original condition. The character of the flow of the river in Colorado is widely variable from year to year and season to season (Master's Findings of Fact "Second" and "Third," pp. 5 and 6 of Master's Report) (Supreme Court's Findings in Kansas v. Colorado, 206 U. S. 46, 115).

Records of official explorations and observations of travelers, traders and early settlers, concerning stream flow conditions along the Arkansas River prior to 1859, appearing at pages 3365-73 of the transcript, (Vol. XX), demonstrate that stream flows were intermittent and at times wholly lost.

During the period of twenty years from 1860 to 1879, stream flow conditions in the Great Plains region were observed by the numerous freighters, goldseekers, homeseekers, and livestock operators who traveled back and forth along and across the river. Observations of some have been preserved (Tr. pp. 3395-3419, Vol. XX).

As therein described, the flow of the Arkansas River, when any flow existed, consisted of occasional floods in some but not all seasons, lasting a few hours to a few days each, and, in some but only a few seasons, of more sustained but smaller flows, lasting a few days to a few weeks.

In none of the twenty years preceding the first attempts in Kansas to irrigate from the Arkansas River, was there a large continuous stream flow or a dependable supply of water. The Stateline flows from Colorado into Kansas, then as now, consisted principally of floods originating in the Colorado foothills and plains drainage areas. In some, but not all, seasons the "June-rise," from mountain runoff, may have overcome the natural channel losses and have traversed the intervening stretch of river so as to have reached Kansas in varying and depleted amounts. Large portions thereof no doubt accomplished the desert

crossing when aided by coincident plains rains and floods. Little or none survived at other times, particularly in the hotter mid-summer months when evaporation rates are maximum. Except for such varying portions of the June-rise, none of the mountain runoff at other and usual stages was of sufficient volume to progress far into the plains or to reach Kansas in any amount. (Tr. pp. 3392-3419, Vol. XX).

During the period from 1859 to 1879 numerous small ditches were constructed and operated along the Arkansas River and its tributaries in Colorado. These were located in mountain valleys and along foothills and plains sections of the main river and tributary streams near the mountains where perennial flows were found and were most readily available for diversion and use, to supply the markets created by hordes of goldseekers (Tr. pp. 3376-3392, Vol. XX). Their names, numbers, and the dates and amounts of their adjudicated water rights appear in Kansas Exhibit 2 (Tr. Vol. VI, p. 904).

Table 31.

Adjudicated Direct Flow Water Rights Arkansas River and Tributaries in Colorado With Priority Dates Senior to 1880.

(Amounts in Cubic Feet per Second).
From Kans. Ex. No. 2.

Water District	Counties-Tributaries	1860-1869	1870-1879	Combined
11	Lake and Chaffee Cos.	273.91	306.30	580.21
13	Custer County	7.84	410.10	417.94
Upstream:	Main R. and Tributaries	281.75	716.40	998.15
12	Largely Fremont Co.	405.35	17.57	422.92
14	Largely Pueblo County	182.50	25.30	207.80
17	Largely Otero County	.....	156.06	156.06
67	Bent and Prowers	.....	31.05	31.05
Main River:	Foothills and Plains	587.85	229.98	817.83
10	Upper Fountain R.	474.79	333.23	808.02
12	Misc. Fremont Co.	72.98	270.77	343.75
14	Misc. Pueblo Co.	33.50	4.10	37.60
15	St. Charles R.	75.35*	75.50	150.85
16	Huerfano R.	173.30	216.46	389.76
17	Misc. Otero Co.	.....	.....	.....
18	Upper Apishapa R.	107.99	74.75	182.74
19	Upper Purgatoire R.	257.96	169.68	427.64
67	Misc. Bent-Prowers	.....	.....	.....
Tributaries:	Entering below mountains	1,195.87	1,144.49	2,340.36
	Basin Totals	2,065.47	2,090.87	4,156.34

*Includes 2.50 cfs. dated 1859.

On each tributary stream the usual seasonal flows are greatly exceeded by the appropriations dated senior to 1880. On the Fountain River, for example, as early as 1864 thirty-seven different ditches had been constructed, in what is now El Paso County and Water District 10, with an aggregate diversion capacity of more than 300 cubic feet per second. This greatly exceeds the total flow of the stream at all times except for infrequent days when cloudbursts visit the territory. As a result, other ditches along the Fountain River lower down in Pueblo County (Water District 14), though constructed during the years 1865 to 1869, are commonly unsupplied with water, and, hence, are properly designated flood water rights, regardless of their early date (Tr. p. 3378, Vol. XX). They divert water,

during crop seasons, only at times of floods, which periodically occur in volumes greatly in excess of all constructed diversion capacities along the stream, and, hence, such floods contribute to the flow of the main stream. Tributaries similar to the Fountain River include the Purgatoire, Apishapa, Huerfano and St. Charles rivers, the mountain supplies of each of which were developed and used early in the 1860 decade. Thereafter none of the so-callled dependable supplies of such tributaries reached the parent stream, and have not been available for appropriation or use along the Arkansas River, either in Colorado or Kansas, since that time, if they ever had been prior thereto (Tr. p. 3379, Vol. XX). There were no early appropriations along plains tributaries entering in Otero, Bent and Prowers counties, such as Big Sandy, Horse Creek, Adobe Creek, Timpas Creek, and Chico Creek, which channels, except as later influenced by return flows from irrigation, have no dependable or perennial volumes, and instead are dry and wholly without water except at times of plains floods. Other miscellaneous tributaries, originating in mountainous areas, include Turkey, Beaver, Eight Mile, Four Mile, Grape, Oak and Hardscrabble creeks. The dependable summer water supply of all these streams was appropriated and used in Colorado as early as the year 1874 (Tr. p. 3380, Vol. XX).

The 1880 decade was characterized by a sequence of seasons that were unusually favorable from the standpoint of precipitation and runoff. Above average amounts of precipitation occurred generally over the Great Plains. At Dodge City, Kansas, during 1881 to 1886, the average annual precipitation exceeded 24 inches. Many plains tributaries became more or less temporarily perennial in the character of their stream flows. Snowfalls in the Colorado mountains was excessive. The years 1885 to 1886 were also unusually high water supply years. These favorable conditions continued through the season of 1887 and partly into the season of 1888, when a reversal in the climate cycle began which created drouth conditions of severe in-

tensity particularly during the period of years from 1889 to 1894 (Tr. pp. 3422-3424, Vol. XX).

Construction of ditches in Kansas for purposes of irrigation along the Arkansas River began about 1880 with the Garden City ditch in Finney County. Thereafter ditches were constructed further upstream in Kearney County, and later in Hamilton County, where, upon reaching the Colorado line, the upstream progression was halted. A total of eight ditches were constructed in three counties. Five of these were in Finney and Kearney counties, constituting the Garden City group. In the order of their construction, and in the order of their location upstream along the river, these were the Garden City, Kansas Farmers, Great Eastern, South Side, and, about 1887, the Amazon. The three ditches in Hamilton County, termed the Syracuse group, were the Ft. Aubrey, Alamo and Frontier. The progressive upstream development of irrigation in Western Kansas, under which each new ditch to be undertaken moved on to the river just upstream from the last ditch previously constructed, was brought about by the laws of the State of Kansas, or the absence of laws relating to appropriations, diversions and uses of water, and of rights of individuals in that regard. (Tr. p. 3454, Vol. XX).

At the same time, in Colorado, as stated in the opinion in the case of Kansas v. Colorado, 206 U. S. 46, 108:

> "certain corporations commenced the work of irrigation on a large scale. In 1884, work was commenced on ditches along the Arkansas River capable of carrying off 450 cubic feet per second, in 1887 others capable of carrying off 1,461 cubic feet per second; and in 1890 still others carrying 1,705 cubic feet per second. Most of these were completed within two years after the commencement of the several works."

Settlers under the recently constructed ditches in Eastern Colorado and Western Kansas in the 1880 decade experienced hardships that attracted nation-wide attention and brought about investigations by committees of Congress in answer to their appeals for aid and relief (Tr. pp.

3485-3488, Vol. XXI). Irrigation interests in Kansas applied to the federal government for aid in the development of the underflow of the Arkansas River and of the underground water resources of that state. Irrigation interests in Colorado asked the federal government to survey reservoir sites in that state, to aid them in their program of storage, which had become necessary in order to irrigate the lands under newly constructed ditches, under which floodwaters and stream flows of winter months, then being unused and wasted, would be conserved (Tr. pp. 3447, 3486, Vol. XXI).

KANSAS ROTATION AGREEMENT AND THE 1916 SETTLEMENT.

The only subsisting enterprises of any importance designed for the diversion of stream flow from the Arkansas River in Kansas consist of a group of ditches, principally in Finney County, Kansas, all within 80 miles from the state line. These are: The Amazon Canal, The South Side Ditch, The Great Eastern Canal, The Farmers' (sometimes called the Kansas or Kansas Farmers') Ditch and the Garden City Ditch. West of this group, through a distance of about sixty miles between the Kansas-Colorado boundary and the Garden City section, the river flows through a stretch of land ill adapted to profitable agriculture and always thinly populated. From the earliest times the river had practically no surface flow during this stretch, the normal flow being absorbed in the sand and even considerable floods being dissipated and lost. Two or three small ditches of comparatively minor dimensions were constructed in this stretch, mostly near the Colorado line, after various years of abandonment and reconstruction, still survive. They have been recently revived by the increase in continuous flow brought about by the return waters now rapidly developing from long continued irrigation within the boundaries of Colorado. The Garden City group already mentioned, however, represents substantially the whole of the irrigation development within the State of Kansas which has survived.

On August 30, 1908, the Finney County Water Users' Association (co-defendant in this case) brought suit in the District Court of Kearney County, Kansas (later removed to the United States Court) seeking an adjudication of priorities of all Kansas ditches diverting from the Arkansas River (Tr. Vol. XXI, pp. 3530 to 3539). This suit between the Kansas ditches was settled by a stipulation dated May 16, 1911, consenting to the entry of a decree under which the divertible waters of the Arkansas River, including the supplies expected to be acquired from the Colorado ditches in the United States Irrigating Company suit, (hereafter mentioned) were to be divided, distributed and rotated as follows:

The Garden City Ditch, 2/21, 1,500 acre feet;
The Farmers Ditch, 5/21, 3,750 acre feet;
Great Eastern Ditch, 6/21, 4,500 acre feet;
South Side Ditch, 4/21, 3,000 acre feet;
Amazon Ditch, 4/21, 3,000 acre feet.

Under the same stipulation-decree a distributing officer was appointed by the court to carry out its terms. This officer after functioning several years was later replaced by an agency of the State of Kansas.

On August 27, 1910, and after the decision in *Kansas v. Colorado*, 206 U. S. 46, which had been rendered in 1907, suit was brought in the United States Court, for the District of Colorado, by the United States Irrigating Company against The Graham Ditch Company, and numerous other public and private corporations, owners of canals and reservoirs, and water rights, in Colorado (Colo. Ex. 1, Vol. I, p. 1). Various Colorado water officials were also named as defendants, but the officials were later dismissed from the suit. The various corporations named as defendants were substantially the same as the individual defendants named as parties in the interstate case of Kansas v. Colorado.

The suit was to establish Plaintiff's rights under certain claims of priorities of appropriation of water in Kansas, and regardless of State lines as against the Defend-

ants' claim of priorities and rights on the Arkansas River. (The case was No. 5578). After presentation of Complainant's testimony and before any testimony had been introduced in behalf of the defendants, the case was settled by contract dated February 19, 1916 (Colo. Ex. 148, Vol. XXI, p. 3517) and dismissed pursuant to the settlement.

The Finney County Water Users Association, a co-defendant in the case now before the court, sought to intervene in case No. 5578 (Colo. Ex. 149, Vol. XXI, p. 3518).

(The Master's finding merely states that the case was dismissed, but makes no mention or reference to the settlement contract.)

(Spec. Master's Report, Finding of Fact "Fourth," p. 9).

The State of Kansas was not a party to the suit brought by the United States Irrigating Company, and was not a party to the 1916 settlement. The State of Kansas, however, in Paragraph Twenty-second of its separate answer in the case now before the Court alleges as part of its claim to an allocation of water from the Arkansas River in Colorado, the priorities and water rights of the Kansas ditches covered by the 1916 settlement.

The Finney County Water Users' Association, co-defendant with the State of Kansas in this case, was not a party to the United States Irrigating Company suit, and was not a party to the 1916 settlement, but has benefited from that settlement because of the rotation agreement and decree hereinabove set out.

The 1916 settlement contract provided that (a) the defendants (the Colorado canals) should recognize priorities of date August 27, 1910, in the Kansas ditches on whose behalf the United States Irrigating Company had sued, namely, the Amazon, South Side, Great Eastern and Garden City Ditches, and the Lake McKinney Reservoir; (b) the defendants should not apply for, or claim priorities for storage purposes on the Purgatoire River, or on the Arkansas River below the mouth of the Purgatoire, as of

an earlier date than August 27, 1910; (c) the defendants should pay the costs of the suit; (d) the defendants should pay the signatory Kansas interests fifty cents per acre then being irrigated in Colorado, and (e) the defendants should pay the signatory Kansas interest the further sum of $30,000. (Colo. Ex. 148, Vol. XXI, p. 3517). The Kansas interests signatory to the settlement contract agreed to accept the priority date as of August 27, 1910, and the quantities of water therein specified as settlement of their relative rights as against Colorado appropriators, and agreed to accept the payments above mentioned, totalling a sum of about $150,000. These payments have been made and accepted long since. (Tr. Vol. XXV, p. 6084). Pursuant to provisions of this settlement contract, no Colorado reservoir or storage development on the Purgatoire River, or on the Arkansas below the mouth of the Purgatoire has been made or attempted by Colorado since that date. On page 15 of the settlement contract it is stated:

> "And whereas, the development of wells and pumping plants on the lands irrigated by the ditches and canals of first parties has proven the existence of large bodies of underground waters commonly known as the underflow, which said waters are available for use in irrigating said lands, as a supplemental and further water supply, in addition to the surface flow of said river,"

(The "lands" above mentioned are the Kansas lands.) On page 20 of the settlement-contract it is stated:

> "This contract shall be upon its final execution, according to its terms, conclusive as to the legal and equitable rights to the use of water from the Arkansas River, as between the signatory parties thereto."

The Finney County Water Users' Association, having been refused permission to intervene in the United States Irrigating Company suit, and having declined to become a party to the settlement contract of 1916, itself brought suit in November, 1916, in the United States District Court, for the District of Colorado, against the Graham Ditch Com-

pany and other canals and water users in Colorado, being substantially the same defendants named in the United States Irrigating Company suit (Colo. Ex. No. 2, Vol. I, p. 9). The number of the Finney County Water Users' Association suit was 6633. The relief sought in this suit was in substance an adjudication of a priority on Plaintiff's behalf as against the Colorado water users. A few years later the same Plaintiff brought another suit (No. 7493) against the Coler Ditch and Reservoir Co., and other Colorado water users not named a defendant in its first suit (Colo. Ex. 3, Vol I, p. 11). Some testimony was taken in these cases, but hearings were discontinued upon the bringing of the present suit of the State of Colorado v. the State of Kansas and the Finney County Water User's Association. The State of Kansas in its claim for relief or cross-bill in this case (Paragraph twenty-second of Kansas answer) alleges as a claim to an allocation of water from the Arkansas River, the alleged priorities set up by The Finney County Water Users' Association in its cases in the District Court.

The Master has recommended that these private suits in the District Court should be dismissed and their further prosecution enjoined, and no exception to this has been filed.

THE 1933 STIPULATION.

In December, 1933, the States of Colorado and Kansas by their respective Governors, Attorneys General, State Engineers, and Counsel in this case, entered into a stipulation, introduced in evidence by both parties (Colorado Ex. 179, Kansas Exhibit 129, Tr. p. 6053, Vol. XXXV; App. "B," pp. 30-35). The Finney County Water Users' Association, co-defendant herein, was a party to the stipulation.

The stipulation recites (1) that the case is pending in the United States Supreme Court; (2) that the construction of the Caddoa Reservoir by the United States was under consideration; (3) that it was the thought of the parties that the reservoir would "enable much of the water that flows in said river past the location of said proposed dam to be stored, regulated and conserved for beneficial use;" (4)

that the parties "recognize the advantages" to be gained from the reservoir "if assured of the protection not only to all rights which they now have and which are involved in the present controversy, but also to their existing water supply in the event said dam" should be constructed and operated prior to the entry of a decree in the pending case; and (5) that it was desirable to provide for the co-operation of the two states and The Finney County Water Users' Association in securing the construction of the dam.

Section One expressed the promise of the parties to use their influence to obtain the construction of the reservoir and then contained this provision:

> "Said parties agree as between themselves to the allocation of the water that might be stored in said reservoir, as hereinafter set forth; it being understood that such allocation shall be subject to the storage and discharge of water stored in such reservoir by the United States of America in order to lessen or avoid damages from floods."

Section Two provided for the allocation of the water:

> "That the construction and operation of said dam and reservoir shall not disturb the status quo of the diversion of water for beneficial use from said Arkansas River by the ditches and canals now constructed and operated in both of the states of Colorado and Kansas. IT IS UNDERSTOOD AND AGREED that in order to maintain the status quo of said diversions as hereinabove referred to there shall be allocated to the State of Kansas for delivery at the Stateline in the Arkansas River from Colorado into Kansas a quantity of water up to 77,000 acre feet annually, of which amount 52,000 acre feet thereof shall be delivered at the State line during the irrigation season from April 1 to October 1 of each year as and when required by the Kansas State water officials, and 25,000 acre-feet thereof to be delivered during the non-irrigating season from October 1 to April 1 at such times and in such amounts as same could be diverted and used for irrigation or

storage; and for irrigation of lands in Colorado below said reservoir a quantity of water up to 160,000 acre feet annually."

Section Three provided that when the river flow below the dam should be insufficient to supply the total amount allocated by Section Two, "then in that event the said waters shall be prorated between Colorado and Kansas in the relation hereinabove in paragraph 2 hereof set forth."

Section Four provides for the allocation of surplus water:

> "After the allocation of water as provided in the next preceding paragraphs, all additional water which may be impounded in said reservoir, excepting, always the amounts of water discharged for flood control purposes, hereinafter referred to, shall constitute surplus and shall be allocated one-half to Colorado and one-half to Kansas, said surplus to be determined April 1, annually, or such other date as may be mutually agreed upon by water officials of the two States, and the amount allocated to each state shall be discharged from said reservoir from time to time on request of the Water Officials of each State respectively for the water allocated to it, but the release of such water on demand shall not be considered as constituting any part of the amounts specified in paragraph 2 herein."

Section Five provides that any exchanges of water between Colorado ditches located below and above the reservoir shall be made only out of surplus and shall be charged against Colorado's share of the surplus.

Section Six states that reservoir flood releases shall not be charged against either state unless such releases coincide with a request by the state.

Section Seven makes the provisions for allocation of water effective "when such dam shall have been constructed and water begun to be stored in said reservoir."

Section Eight provides:

> "This stipulation is without prejudice to the claims of either party hereto in the above specified case, and shall be subject to the decision of the Supreme Court of the United States as to the respective rights of the parties hereto to water flowing in the Arkansas River, or stored in said reservoir."

Section Nine gives joint control of the storage and discharge of reservoir waters to the two states.

The Master finds the Stipulation to be "not binding" upon either State, nor to be considered in the adjudication of this suit. (Finding "Thirteen," Conclusion "Seven" and paragraph "Six" of proposed Decree, pp. 13, 16, 21 Master's Report.)

CADDOA RESERVOIR AND ITS UTILIZATION IN SETTLEMENT OF THIS CONTROVERSY.

During the pendency of this action and after a considerable part of the evidence on both sides had been introduced, a new element came into the picture which might affect the regulation and control of the surplus waters of the Arkansas River. This was by the construction by the Federal government of what is commonly known as the Caddoa Reservoir on the main River channel about 48 miles west of the Colorado-Kansas state line.

The Master characterizes this as of "limited life" and "a temporary achievement" (page 14, Master's Report), and "not binding upon either of said states" and "nor to be embodied in a decree in the present suit." (Master's Report, pp. 16, 21).

A description of the Reservoir and its probable operation and effect on the river flow and a plan to equitably allocate between Kansas and Colorado the use of waters made available are shown in Colorado Exhibits 207-229, (Tr. pp. 6633-6748, Vols. XXXVII and XXXVIII; App. "B," pp. 60-71).

Unused water resources and wasted stream flows crossing the state line and passing Garden City, together with needs for additional water supplies, under normal climatic conditions, to properly irrigate the lands under constructed enterprises in the Arkansas River basin in Colorado, have been the subjects of investigations heretofore and now being made by Colorado and its citizens and water users. (Tr. p. 1739, Vol. X). In brief, the said investigations disclose, first, that the water supplies of ditches with points of diversion below Caddoa are dependent, largely, on flood runoff from plains areas, and that water supply deficiencies under such ditches can best be remedied by reservoirs to control such floods, regulate the stream flows, and conserve water resources that heretofore, being unused, were wasted, and at times were damaging to lands and property along the stream channels; and, second, that water supply deficiencies under ditches upstream from Caddoa can be remedied, as a rule, only by importations of additional waters from other streams, (Tr. pp. 618-620, Vol. IV), i. e., from the headwater tributaries of the Colorado River, which originates west of the Continental Divide and flows into the Gulf of California.

Operations under the Colorado Canal system (Twin Lakes or Bob Creek Canal) with its headgate 125 miles west of the Colorado-Kansas State line proved so unsatisfactory, and the quantities of water diverted and used were so inadequate, as to cause declines in irrigated acreages and severe crop losses in all years except at intervals when large rainfall and runoff resulted in undependable water supplies. This system constructed its Colorado or Bob Creek Canal, beginning June 9, 1890; Lake Henry Reservoir in 1891, which was later enlarged in 1909; Lake Meredith Reservoir in 1898; and Twin Lakes Reservoirs in 1896 and 1897. In spite of its relatively large storage provisions, the diversions and uses of water under the system were inadequate. The Colorado Canal system undertook the construction of an importation project, involving a tunnel at Independence Pass at an expense of several million dollars, (Tr. pp. 3612-13, Vol. XXII) which will add about one acre-foot per acre to the water supplies derived from local sources. Deliveries by this importation project began in May of 1935 (Colorado

Exhibit 194, Tr. Vol. XXXVII, p. 6513; App. "B," pp. 36-41).

Investigations of the possibilities of flood control, water conservation, and importations to the Arkansas River, and of the engineering and economic feasibility of such projects, previously made by the Colorado State Engineer, in co-operation and with funds provided in part by individuals and organizations of water users in the Arkansas Valley in Colorado, include the so-called Amsley Investigations of water utilization and disposal during the years 1922 to 1925; transmountain diversion investigations as reported June 27, 1927 (Tr. pp. 3599-3622, Vol. XXII); and reservoir investigations of sites on Purgatoire River and at Caddoa on the Arkansas River, published in 24th Biennial Report (1926-1927) of the Colorado State Engineer (Tr. p. 1739, Vol. X).

With respect to flood control and water conservation possibilities in the Arkansas River basin, the investigations of the Colorado State Engineer, such as outlined in the 24th Biennial Report (Tr. p. 1739, Vol. X), covered reservoir sites, among which were Purgatoire Reservoir No. 2, on the lower Purgatoire River in Colorado; Caddoa Reservoir, on the Arkansas River in Eastern Colorado; Bear Creek, an off-channel site in Western Kansas; and others in Eastern Colorado and Western Kansas. These were again and further investigated by the War Department, U. S. Corps of Engineers, and were included in its Flood Control Report on the entire Arkansas River and its tributaries, being House Document No. 308, 74th Congress, 1st Session, printed August 24, 1935, and appearing herein as Colorado Exhibit 201-(a), Tr. Vol. XXXVII, p. 6592). When, in 1933, it appeared that construction of Caddoa Dam and Reservoir by the United States might be recommended by the Corps of Engineers, U. S. Army, and might be authorized by Congress, provided the States of Colorado and Kansas would settle the long-standing controversy between them, concerning the relative rights of the respective states in and to the use of waters of the interstate stream, the officials of the two states and counsel

for all parties herein, entered into an agreement dated December 18, 1933, referred to as the Stipulation of 1933, and hereinabove discussed.

Construction of Caddoa Dam and appurtenant works, by the War Department, Corps of Engineers, U. S. Army, was thereupon and thereafter authorized by Congress in the Flood Control Act of June 22, 1936, to provide for flood control and water conservation in Colorado and Kansas. Maintenance and operation of the project after its completion, by the Flood Control Act of 1938, was placed under the supervision of the Corps of Engineers, U. S. Army. Costs of lands, rights-of-way, damages, railroad and other relocations, and appurtenant works, declared in the 1938 Flood Control Act to be parts of the construction costs, were thereby assumed by the United States, and appropriations for construction purposes were made in the 1938 and subsequent Flood Control Acts. Construction work on Caddoa Dam began in 1940. About that time, by Act of Congress, the official name was changed to the "John Martin Reservoir Project," though for convenience the original name of Caddoa is herein retained.

General location and design plans of Caddoa Dam and Caddoa Reservoir are shown by Colorado Exhibits 198 and 199 (Tr. Vol. XXXVII, pp. 6518-6580). Project plans contemplate a reservoir, when completed, of a total capacity of about 655,000 acre-feet. (The preliminary figure mentioned in the Stipulation of 1933 was 680,000 acre-feet). About 270,000 acre-feet of the said total capacity, between elevations 3,870 and 3,851 feet, termed the flood pool, is reserved for flood control. Regulations to govern operations of the flood pool, announced by the Corps of Engineers, U. S. Army, provide that waters impounded therein, incident to flood damage prevention, will be released, without regard to then prevailing irrigation needs, at rates up to the conveyance capacity of the downstream river channel, estimated at about 10,000 cubic feet per second. (Tr. p. 6524, Vol. XXXVII.)

The said flood pool has been designed to control the greatest flood of record to within the bankful capacity of the downstream channel. This design flood occurred June

2-5, 1921, and had a crestflow at Caddoa of 170,000 cubic feet per second and a duration at that stage of about 3 hours. Flood control benefits, measured by the savings in flood damages to be prevented by Caddoa Reservoir, as determined by the Corps of Engineers, U. S. Army (Colorado Exhibit 201-a; Tr. p. 6592, Vol. XXXVII), will be:

To Colorado property	$35,990 annually; and,
To Kansas property	97,329 annually.

The remaining storage space in Caddoa Reservoir, as designed and being constructed, namely, that below El. 3,851 ft., amounting initially, prior to its reduction by siltation, to about 385,000 acre-feet (Colorado Exhibits 200, 201, Tr. Vol. XXXVII, pp. 6582-6592), termed the conservation pool, is allocated to conservation storage. No regulations with respect to operation of the conservation pool have been issued by the Corps of Engineers, U. S. Army, or any other agency.

Irrigation benefits to be derived, when Caddoa Reservoir is completed and comes into operation, are of two kinds. In the first category are those, for convenience termed regulation benefits, which involve waters historically used by ditches downstream in Colorado and Kansas, which will result from or be created through regulation, or temporary storage, by making the said waters available for use more nearly in accordance with irrigation needs. Those in the second category involve waters historically unused and wasted, that, being conserved, are to become available for additional diversion and increased use. These unappropriated waters by the Stipulation of 1933 are to be divided equally between the two states. In some seasons of above-average rainfall and runoff, the surplus supplies thus captured and conserved may be of considerable extent, whereas in other seasons of subnormal or drouth conditions there will be no surplus water impounded. (Colo. Ex. 221, 224, Tr. p. 6750, Vol. XXXVIII).

In order to understand the nature and extent of the surplus supplies and conservation benefits of Caddoa Reservoir, it is necessary, by reason of fluctuating natural conditions, to take into account a substantial period of years.

Records covering the 31-year period 1908 to 1938 have been assembled, analyzed and presented. Precipitation averages during the study period are shown by Colorado Exhibit 202, (Tr. Vol. XXXVII, p. 6602; App. "B," p. 52), the said period averages being in substantial agreement with longer time averages, such as the record of 68 years at Pueblo, and 75 years at Las Animas. Average annual temperatures during the study period are shown by Colorado Exhibit 203 (Tr. Vol. XXXVII, p. 6603; App. "B," p. 53). Stream flows by months, seasons and years, as recorded at the principal stream gaging stations of Canon City, Pueblo, La Junta, Lamar, Stateline, and Garden City, on the Arkansas River, and on the Purgatoire River are shown by Colorado Exhibit 204 (Tr. Vol. XXXVII, p. 6605; App. "B," pp. 54-58) and as calculated at Caddoa, are shown by Colorado Exhibit 207 (Tr. Vol. XXXVII, p. 6633).

Stateline flows as recorded daily are portrayed by Colorado Exhibit 208 (Tr. Vol. XXXVII, p. 6639; App. "B," p. 60), and are tabulated, as monthly, seasonal and yearly quantities in 1,000 acre-feet units, in Colorado Exhibit 209 (Tr. Vol. XXXVII, p. 6639; App. "B,", p. 61). Stateline flows originate, in part, above the site of Caddoa Reservoir, and in part below. Those originating upstream from Caddoa, and accruing in amounts not in excess of the reservoir's conservation capacity, can become subject to release as needed. Stream flows and water supplies entering below Caddoa cannot be controlled or conserved by the proposed reservoir (Tr. pp. 6642-6643, Vol. XXXVII).

Kansas Exception Number III, to the Master's Report, seeks to have this Court declare that the larger portion of the water supply passing across the state line into Kansas can be captured and conserved in Caddoa Reservoir.

Only about one-half of the Stateline flows historically recorded have passed the site of Caddoa Reservoir—portions of which are in excess of conservation capacity—and the remaining one-half entering the Arkansas River below that point, is not subject to control by Caddoa Reservoir. Relations between the Caddoa and Stateline flows, in the average year of the 1908 to 1938 period, together with average quantities diverted from and accretions to the inter-

vening river section, are summarized (from Colorado Exhibits 209, 210; Tr. Vol. XXXVII, pp. 6640-6644; App. "B," pp. 61, 62) in the following:

TABLE 32

Average Discharge of Arkansas River at Caddoa and at Stateline

Diversions and Accretions along River Section.

(Values in Acre-Feet are Averages for 1908-1938)

	Summer	Winter	Annual
Flow at Caddoa	233,100	62,600	295,700
Diversions of Colorado Ditches	117,800	41,100	158,900(a)
Balance—Undiverted	115,300	21,500	136,800
Accretions to Section	65,200	58,700	123,900(b)
Flow at Stateline	180,400	80,300	260,700

(a) Comparable with 160,000 acre-feet specified in 1933 Stipulation.
(b) Accretions below Caddoa constitute about ½ of total Stateline flow.

Accretions to the flow of the Arkansas River between Caddoa and the Stateline consist of tributary inflows and return flows. Tributary inflows are the intermittent run-off, due to periodic intense rainfalls, from the drainage area of about 5,600 square miles tributary to that stretch of river (Colorado Exhibit 205, Tr. Vol. XXXVII, p. 6607; App. "B," p. 59). Together the tributary inflows and return flows, in addition to overcoming the natural consumption or conveyance losses of the river section, are of sufficient magnitude to deliver an average of 123,900 acre-feet at the Stateline. Neither the tributary inflows nor the return flows causing the said accretions or river gains, are subject to capture, control, regulation or conservation by the proposed Caddoa Reservoir.

The said approximate half of the Stateline flows originating below Caddoa is not possible of material depletion by future operations in Colorado. The return flows, constituting a large if not a major share of the said downstream accretions, being the water supplies most largely diverted and used in Kansas, cannot be further depleted in Colorado, since they enter the river section below the points of diversion therefrom of the Colorado ditches.

Such return flows on the contrary will inevitably be increased to substantially the same extent that the diversions of the Colorado ditches below Caddoa, and of the Ft. Lyon system, are increased through operations of the proposed Caddoa Reservoir.

Stateline flows historically recorded during 1908 to 1938, as portrayed by Colorado Exhibit 208 (Tr. Vol. XXXVII, p. 6639; App. "B," p. 60) and tabulated in Colorado Exhibit 209 (Tr. Vol. XXXVII, p. 6640, App. "B," p. 61) are in part undivertible by constructed ditches in Kansas. At times of plains floods the Stateline flows occur at rates in excess of 2,000 cubic feet per second, which is the approximate aggregate diversion capacity of the Kansas ditches. Segregations of the historic Stateline flows according to divertibility, and with respect to the quantities used and unused in Kansas (summarized from Colorado Exhibits 211 to 215 Tr. Vol. XXXVII, pp. 6646-6675; App. "B," pp. 63-67), are shown in the following:

Table 33.

Divertible and Undivertible Stateline Flows
Quantities Used and Unused in Kansas.

(Values in Acre-Feet are Averages for 1908-1938)

	Summer	Winter	Annual
Total Stateline Flow	180,400	80,300	260,700
Undivertible Flood Crests (a)	71,800	14,300	86,100
Divertible by Kansas Ditches	108,600	66,100	174,700
Diverted in Kansas	57,100	27,800	84,900
Accretions to Garden City	—6,400	1,600	—4,800
Divertible Water Used (b)	63,500	26,200	89,700(b)
Divertible Water Unused	45,100	39,900	85,000
Undivertible, Unused	71,800	14,300	86,100
Unused Garden City Outflow	116,900	54,100	171,000

(a) Flows at rates in excess of 2,000 c.f.s. classed as undivertible by constructed ditches in Kansas.

(b) As of Stateline: Includes Holly drain water (in part used by Frontier ditch), and, except for on demand provision of 1933 Stipulation, is comparable with 77,000 acre-feet therein specified as status quo allocation to Kansas.

As indicated by Table 33, the total uses of Arkansas River water heretofore made in Western Kansas, between

the Stateline and Garden City, by diversions from the river channel, by means of wells and pumps, and to satisfy conveyance losses, together have been equivalent to about one-third of the stream flows crossing the Stateline. Another one-third may be considered undivertble. The remaining third, though divertible, has not been used. So that two-thirds of the total Stateline flow, being unused, and having been permitted to flow past Garden City, has been wasted and without benefit. Excluding the so-called undivertible stream flows, approximately one-half of the divertible water supplies entering Kansas have been unused and wasted, because sufficient storage capacity has not been provided in Kansas. (Tr. p. 6652, Vol. XXXVII).

Except for the construction of Lake McKinnie Reservoir in 1906-1907, throughout the period from the original to the pending interstate litigation, the reservoir sites and opportunities in Western Kansas have remained undeveloped.

Tests of the percents of silt in suspension in various stages of the flow of the Arkansas River at the site of Caddoa Reservoir (Colorado Exhibit 216, Tr. Vol. XXXVIII, p. 6682), indicate that siltation and loss of storage capacity will occur at the rates or in the relations indicated by Colorado Exhibit 217, (Tr. Vol. XXXVIII, p. 6686). Had the reservoir functioned during the period 1908 to 1938, the deposited sediments would have averaged 6,331 acre-feet annually (Colorado Exhibit 218, Tr. Vol. XXXVIII, p. 6688), and the water holding capacity of the conservation pool would have declined from 382,600 acre-feet, as of January 1, 1908, to 186,350 acre-feet, as of December 31, 1938. Under such climatic and stream flow conditions, the useful effective life of the conservation pool will approximate 60 years. Major floods, as in 1921, cause excessive erosion upstream and will deposit large quantities of sediment in the reservoir. In the absence of such a major flood, useful life may approximate 80 years. Conversely, if several such floods should occur, useful life may be decreased to 40 years or less. Construction of the project was justified on the belief or assumption that major

and damaging floods will occur in the future, and hence their siltation effects must be anticipated.

Extension of the effective life of the conservation pool in Caddoa Reservoir, beyond the periods above mentioned, can be accomplished only by the construction of flood control reservoirs on each of the upstream tributaries where such major and damaging floods originate. The preservation of such tributary reservoir capacities, in turn, will require flood control, soil erosion prevention, and runoff retardation works upstream therefrom.

Evaporation losses from water surfaces at Caddoa Reservoir will average about 56 inches in depth annually (Colorado Exhibit 219, Tr. Vol. XXXVIII, p. 6689). After allowances for the effects of precipitation on the water surfaces, evaporation will consume 3.62 acre-feet of water annually for each acre of exposed water surface area. Such areas will vary with the quantities of water impounded in the reservoir, and hence will vary somewhat with administration and operation plans and programs. Several different operations plans are possible, under the Stipulation of 1933, and have been studied by the Colorado Water Conservation Board, as testified to by its chief engineer. Each of said operations plans, however, showed evaporation losses approximating 15,000 acre-feet annually. The Operations Plan described by the witness C. L. Patterson, involved evaporation losses varying by years from 5,000 to 27,200 and averaging 14,800 acre-feet annually during the 31-year study period (Colorado Exhibit 220, Tr. Vol. XXXVIII, p. 6694).

Under any plan of operation that might be devised or adopted, the conservation pool will vary from empty in some seasons to overflowing in others. The storage status at the close of each winter season, and at the end of each summer month, as it would have occurred, during the period 1908-1938, is shown in Colorado Exhibit 221, (Tr. Vol. XXXVIII, p. 6700). Of the 186 summer months in the 31-year study period, there were 27 months, or about one-seventh of the time, when no storage would have been on

hand, and no water available for release. At such times the ditches downstream in Colorado and Kansas, as in the past, would have been dependent on the stream flows passing through the reservoir and on the accretions entering below Caddoa. Including the said 27 months when available storage would have been zero, there were 36 others, or a total of 62 summer months in all, representing about one-third the time, when storage on hand would have been less than 40,000 acre-feet. At such times the supplies of water available to ditches downstream in Colorado and Kansas, in addition to the stream flows arriving at and entering below Caddoa, would be augmented by whatever releases would have been made from storage. Together, the stream flows arriving at the reservoir, the releases made therefrom if any, and the water supplies entering below Caddoa, constitute the resources which, under the 1933 Stipulation, are to be divided between the two states as therein specified.

The quantities of water released from the flood pool for flood control purposes, being waters in excess of the storage capacity of the conservation pool, under the Stipulation of 1933,

> "shall not be charged to either state, unless such releases are coincident with the request for water on behalf of said state or the use and diversion by the ditches in such state, and then only to the extent of the request or use so made" (Par. 6).

For convenience such flood pool releases are termed spills. Frequencies of such spills during 1908-1938 would have occurred in 9 of the 31-years. Total quantity of water spilled would have been 1,731,300 acre-feet,—equivalent to an average of 55,800 acre-feet per year. No spills would have occurred in the remaining 22 years of the study period, i. e. during the cycles 1908 to 1913; 1917 to 1920; 1925 to 1926; and 1929 to 1938. Had the study extended to date, no spills would have occurred in 1939 or 1940, but substantial spills would have resulted from the above-average precipitation over and runoff from plains areas in 1941 and 1942.

In the Stipulation of 1933 one of the recognized benefits to be derived from Caddoa Reservoir is the regulation of stream flows, to make the quantities of water previously diverted, defined therein as status quo allocations, available for use as nearly as may be in accordance with irrigation needs. To attain the objectives of maximum waste prevention, and greatest benefit from water utilization, it is necessary that stream flows in winter months be stored, so far as possible, and be used in summer months or crop growing seasons. Such winter storage quantities are indicated in Colorado Exhibit 221 (Tr. Vol. XXXVIII, p. 6700), by the gains from the end of September of one year to the end of March of the following year. After allowances for evaporation losses and reservoir spills, the net gain, due to winter storage, would have averaged 31,800 acre-feet per season. The storage of water in winter months would greatly reduce the winter diversions of Colorado ditches, but would not affect the quantities historically diverted in winter by ditches in Kansas, which have been and will continue to be supplied by return flows entering below Caddoa. However, under the plan, winter storage water would be released to meet both the summer diversion schedules of Colorado ditches and the summer delivery schedules to Kansas. These schedules were so devised that the Colorado ditches will receive in summer about two-thirds of the said winter storage, and Kansas will receive in summer the remaining one-third thereof. This contemplates a division, between the two states, of the regulation benefits of Caddoa Reservoir, in the same proportions, as specified in the 1933 Stipulation, for dividing the stream flows to protect existing rights and water supplies used in the two states. Winter storage accounts for approximately 20,000 acre-feet per year of the calculated surplus supplies and conservation benefits. Should the practice of winter storage be prohibited, by interpreting the provisions of the 1933 Stipulation, relative to the maintenance of status quo of diversions, to mean that winter diversions of Colorado ditches must continue in the future as in the past, then each state will lose about 10,000

acre-feet per year of surplus water that can be saved and will lose the conservation benefits that can be and should be created thereby.

Caddoa Reservoir operations will affect the character and the amount of the flows of the Arkansas River below the site, at the headgates of ditches downstream in Colorado, at the Stateline, and in Western Kansas, and, while the total flow will be diminished, the usable water supplies will be increased in amount. As indicated in Colorado Exhibit 223 (Tr. Vol. XXXVIII, p. 6628, App. "B," p. 68) total Stateline flows will be diminished 51,800 acre-feet in the average year. This diminution is attributable, to the extent of 15,900 acre-feet, to Caddoa Reservoir itself (14,800 acre-feet of evaporation loss, plus 1,100 acre-feet of carryover storage at the end of the study period), and, to the extent of 35,900 acre-feet, to the stream depletions in Colorado (Colorado Exhibit 225, Tr. Vol. XXXVIII, p. 6734, App. "B," p. 70), resulting from the additional diversions and increased uses in that state (Colorado Exhibit 227, Tr. Vol. XXXVIII, p. 6744), of its half of the surplus supplies to become available by reason of operations of the conservation pool. By reason of the said increased upstream depletions in Colorado and the said losses of water at Caddoa Reservoir, together withholding 51,600 acre-feet from the Stateline flows, the historically recorded average flow at the Stateline, of 260,700 acre-feet, will be diminished to an average during a similar climatic cycle in the future of 208,900 acre-feet annually.

The reduction in total Stateline flow, instead of adversely affecting or injuring Kansas, will in fact be beneficial to the irrigation interests of that state, not only because of savings in flood damages, but also because the usable Stateline flows will be increased in amount. The increase in usable Stateline flows, averaging 39,600 acre-feet, will increase the historically recorded average of 89,700 acre-feet to an after-Caddoa average of 129,300 acre-feet annually. All the said increase will become available for

additional diversions in summer thus increasing the usable summer supply from the historically recorded average of 63,500 acre-feet, to an after-Caddoa average of 103,100 acre-feet per season (Colorado Exhibit 224, Tr. Vol. XXXVIII, p. 6730, App. "B," p. 69). Had the analysis been based on a strict and technical interpretation of the Stipulation of 1933, the increase in usable water supplies to become available in Kansas would have amounted to 52,300 acre-feet per year and per summer season, that being the increase above the values of 77,000 acre-feet annually, and of 52,000 acre-feet per summer season, specified in said Stipulation.

Considered as ten-year averages, the surplus supplies to become available for additional diversion and increased use, or the conservation benefits of Caddoa Reservoir would have been divided equally between the two states under all the widely variable precipitation and stream flow conditions of the study period. During the first ten years (1908-1917), total benefits would have averaged 83,900 acre-feet per year, and would have been divided, 42,700 acre-feet per year, or 50.9% to Kansas, and 41,200 acre feet per year, or 49.1% to Colorado (Colorado Exhibit 226, Tr. Vol. XXXVIII, p. 6736, App. "B," p. 71). During the ten-year period of largest average surplus supplies, from 1916 to 1925, total benefits would have averaged 100,500 acre-feet per year, and would have been divided, 54,100 acre-feet per year, or 53.8% to Kansas, and 46,400 acre-feet per year, or 46.2% to Colorado. During the ten-year period of least surplus supplies, from 1929 to 1938, total benefits would have averaged 57,000 acre-feet per year, and would have been divided 28,700 acre-feet per year, or 50.4% to Kansas, and 28,300 acre-feet, or 49.6% to Colorado. Over the entire 31-year study period, total conservation benefits would have averaged 75,500 acre-feet per year, and would have been divided, 39,600 acre-feet per year, or 52.5%, to Kansas, and 35,900 acre-feet per year, or 47.5% to Colorado.

The above mentioned surplus supplies to become available for additional diversions and increased use, and the said conservation benefits to be created by operations of the conservation pool in the proposed Caddoa Reservoir, which, under the Stipulation of 1933, are to be divided equally between the two states, were calculated from the stream flow and diversions records of the 1908 to 1938 period, on the assumption that Caddoa Reservoir had been constructed to commence operations as of October 1, 1907. During the study period, more than half the initial capacity of the conservation pool would have been destroyed by siltation. Had the study been extended to cover a second similar climatic cycle, it would have been shown that reservoir spills would have been increased in frequency and average amount, due to the diminished and declining storage space, and that the surplus supplies captured, and the conservation benefits created, would have decreased in average amount, until, at the end of the second 34-year period, there being no remaining storage space, there would be no surplus capture and no conservation benefits available for allocation or diversion between the the states. Instead, both states would then be dependent on the unregulated stream flows, and their uses of water from the interstate stream would again revert to the conditions indicated by the recorded historical relations heretofore existing;

Under the variable conditions of rainfall and runoff, and of irrigation needs, imposed by nature on that part of the Arkansas Valley, in Eastern Colorado and Western Kansas, to be affected by the construction and operation of Caddoa Reservoir, it is necessary and desirable that, as indicated in the Stipulation of 1933, both the maintenance of status quo diversion relations and the division between the States of the surplus supplies and conservation benefits of Caddoa Reservoir, be carried out on the basis of long time averages. To that end, some method of accounting is essential, to permit of departures, within limitations, from the specified average relations, and to

include a system of monthly, seasonal, annual, and accumulative credits and debits (Tr. pp. 6708, Vol. XXXVIII).

Respectfully submitted,

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